Grant County

Hazard Mitigation Plan Update
Volume 1: Planning-Area-Wide Elements

December 2013

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HAZARD MITIGATION PLAN UPDATE
VOLUME 1: PLANNING-AREA-WIDE ELEMENTS

December 2013

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Grant County
Hazard Mitigation Plan Update;
Volume 1—Planning-Area-Wide Elements

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Because Grant County is threatened by a number of natural and technological hazards, it is important to mitigate risk before a disaster occurs. The 2013 Grant County Hazard Mitigation Plan Update replaces the 2006 version. It remains a multi-jurisdictional planning effort following the process outlined by the Disaster Mitigation Act of 2000. The plan will continue to be updated and expanded over time to meet the needs of planning partners including municipalities, special purpose districts, stakeholders, and citizens.

The planning partners were invited in 2011 to participate in this update. Their participation helps meet Disaster Mitigation Act compliance, fosters a pro-active approach to emergency management planning and may assist their respective jurisdiction during the recovery phase of potential disasters.

PART 1—THE PLANNING PROCESS

CHAPTER 1.
INTRODUCTION TO THE PLANNING PROCESS

1.1. WHY PREPARE THIS PLAN?

1.1.1 The Big Picture

Hazard mitigation is defined as a way to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster through long- and short-term strategies. It involves strategies such as planning, policy changes, programs, projects, and other activities that can mitigate the impacts of hazards. The responsibility for hazard mitigation lies with many, including private property owners, business and industry, and local, state, and federal government.

The federal Disaster Mitigation Act (DMA) of 2000 (Public Law 106-390) required state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. Prior to 2000, federal disaster funding focused on disaster relief and recovery, with limited funding for hazard mitigation planning. The DMA increased the emphasis on planning for disasters before they occur.

The DMA encourages state and local authorities to work together on pre-disaster planning, and it promotes sustainability for disaster resistance. “Sustainable hazard mitigation” includes the sound management of natural resources and the recognition that hazards and mitigation must be understood in the largest possible social and economic context. The enhanced planning network called for by the DMA helps local governments articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk reduction projects.

1.1.2 Local Concerns

Several factors initiated this planning effort for Grant County and its planning partners:

- Limited local resources make it difficult to be pre-emptive in risk reduction initiatives. Being able to leverage federal financial assistance is paramount to successful hazard mitigation in the area.
- The partners wanted to be proactive in its preparedness for the probable impacts of natural hazards.

With these factors in mind, Grant County committed to the preparation of the plan by attaining grant funding for the effort and then securing technical assistance to facilitate a planning process that would comply with all program requirements.

1.1.3 Purposes for Planning

This hazard mitigation plan update identifies resources, information, and strategies for reducing risk from natural hazards. Elements and strategies in the plan were selected because they meet a program requirement, and because they best meet the needs of the planning partners and their citizens. One of the benefits of multi-jurisdictional planning is the ability to pool resources and eliminate redundant activities within a planning area that has uniform risk exposure and vulnerabilities. The Federal Emergency Management Agency (FEMA) encourages multi-jurisdictional planning under its guidance for the DMA. The plan will help guide and coordinate mitigation activities throughout Grant County. The plan was developed to meet the following objectives:

- Meet or exceed requirements of the DMA.
- Enable all planning partners to continue using federal grant funding to reduce risk through mitigation.
- Meet the needs of each planning partner as well as state and federal requirements.
- Create a risk assessment that focuses on Grant County hazards of concern.
- Create a single planning document that integrates all planning partners into a framework that supports partnerships within the County, and puts all partners on the same planning cycle for future updates.
- Meet the planning requirements of FEMA's Community Rating System (CRS), allowing planning partners that participate in the CRS program to maintain or enhance their CRS classifications.
- Coordinate existing plans and programs so that high-priority initiatives and projects to mitigate possible disaster impacts are funded and implemented.

1.2. WHO WILL BENEFIT FROM THIS PLAN?

All citizens and businesses of Grant County are the ultimate beneficiaries of this hazard mitigation plan update. The plan reduces risk for those who live in, work in, and visit the County. It provides a viable planning framework for all foreseeable natural hazards that may impact the County. Participation in development of the plan by key stakeholders in the County helped ensure that outcomes will be mutually beneficial. The resources and background information in the plan are applicable countywide, and the plan's goals and recommendations can lay groundwork for the development and implementation of local mitigation activities and partnerships.

1.3. HOW TO USE THIS PLAN

This plan has been set up in two volumes so that elements that are jurisdiction-specific can easily be distinguished from those that apply to the whole planning area:

- **Volume 1**—Volume 1 includes all federally required elements of a disaster mitigation plan that apply to the entire planning area. This includes the description of the planning process, public involvement strategy, goals and objectives, countywide hazard risk assessment, countywide mitigation initiatives, and a plan maintenance strategy.
- **Volume 2**—Volume 2 includes all federally required jurisdiction-specific elements, in annexes for each participating jurisdiction. It includes a description of the participation requirements established by the Steering Committee, as well as instructions and templates that the partners used to complete their annexes. Volume 2 also includes "linkage" procedures for eligible jurisdictions that did not participate in development of this plan but wish to adopt it in the future.

All planning partners will adopt Volume 1 in its entirety and at least the following parts of Volume 2: Part 1; each partner's jurisdiction-specific annex; and the appendices.

The following appendices provided at the end of Volume 1 include information or explanations to support the main content of the plan:

- Appendix A—A glossary of acronyms and definitions
- Appendix B—Public outreach information, including the hazard mitigation questionnaire and summary and documentation of public meetings.

- Appendix C—A template for progress reports to be completed as this plan is implemented
- Appendix D—Plan Adoption Resolutions from Planning Partners

CHAPTER 2.
PLAN UPDATE—WHAT HAS CHANGED

2.1. THE 2006 PLAN

The 2006 Grant County Hazard Mitigation Plan identifies vulnerability to hazards across the entire county and the planning process used to mitigate hazards. Incorporated jurisdictions and special purpose district were invited to participate. Those that formed the steering and planning committees assisted in jurisdiction-specific information pertaining to assessing risk and identifying initiates to mitigate risks. *Unless otherwise indicated, previous mitigation plan initiatives are not replaced by this plan update.*

2.2. WHY UPDATE?

Title 44 of the Code of Federal Regulations (44CFR) stipulates that hazard mitigation plans must present a schedule for monitoring, evaluating, and updating the plan. This provides an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. A jurisdiction covered by a plan that has expired is not able to pursue elements of federal funding under the Robert T. Stafford Act for which a current hazard mitigation plan is a prerequisite.

2.3. THE UPDATED PLAN—WHAT IS DIFFERENT?

The updated plan differs from the initial plan in a variety of ways:

- The plan in general was reorganized for ease in review and use.
- The Risk Assessment has been updated to include a more detailed critical facilities analysis. HAZUS Comprehensive Data Management System was enhanced with the Critical Infrastructure Key Resources data, and was used when applicable.
- This plan update focuses on natural hazards and explores them in detail
- The former plan utilized Mitigation 20/20 software to assess risk and estimated values of structures at risk.

Table 2-1 indicates the major changes between the two plans as they relate to 44 CFR planning requirements.

**TABLE 2-1.
PLAN CHANGES CROSSWALK**

44CFR Requirement	2006 Plan	Updated Plan
Requirement §201.6(b): In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: (1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval; (2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and (3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.	Advertised public review meetings: 1/25/06 at the Moses Lake Fire station and 2/2/06 at Ephrata City Hall. Additionally there were non-advertised opportunities for public review. The planning process was open to county government, all municipalities, fire districts, school districts, local industry, port and utility districts. Kittitas, Adams, Chelan, and Franklin Counties were contacted for reference and support to the planning process. The plan shared local land use and Growth Management Act planning and building and fire code processes, and local emergency response plans.	Public review meetings were sent to the Grant County newspaper of record for 4/16/13 Quincy Fire District 3 Station and for 4/23/13 Big Bend Community College in Moses Lake. Public review and comment was available on the Grant County Department of Emergency Management webpage.
§201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	The plan included county-wide risk assessments. These assessments were conducted utilizing a combination of planning partner knowledge and records and Mitigation 20/20 assessment forms and software.	This portion of the plan was significantly enhanced. During this update cycle, the County and its jurisdictions utilized HAZUS, when applicable. The Risk Assessment also includes updated CIKR information, which was utilized in the risk analysis.
§201.6(c)(2)(i): [The risk assessment shall include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	.The plan included natural and technological hazards affecting the planning area. The process researched historical hazard and disaster occurrences. Future probabilities were analyzed and shared in the plan	All disaster events occurring since the last plan edition were included within the plan update. Technological hazards were not included in this update but there are plans to revise and expand on these hazards between plan updates. Probability is address in the frequency and future trends sections of each natural hazards profile.

TABLE 2-1
PLAN CHANGES CROSSWALK

44 CFR Requirement	2006 Plan	Updated Plan
§201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community	Jurisdiction-specific vulnerability assessments were carried out by the planning partner. Mitigation 20/20, SHELDUS, and other available data were also used.	Each hazard of concern was profiled and updated with current information, utilizing the best available science in its profile and risk development. Additionally, HAZUS was utilized to acquire hazard-specific information.
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods	The most recent FEMA Flood Insurance Study information available at time of plan was for September 30, 1988.	Updated NFIP information was provided, including CRS information and flood claims. The updated plan includes general FIRM information from February 8, 2009 and FEMA flood data from 2009 was also used for mapping.
Requirement §201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area.	The plan described vulnerability by neighborhood, estimated number, value, and percentage of structures at risk. Critical facilities were inventoried, not published.	The risk assessment includes an assessment of the structures county wide, including general building stock and critical facilities.
Requirement §201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) and a description of the methodology used to prepare the estimate.	Potential dollar losses were estimated by the average value of structures per neighborhood in the jurisdictions and unincorporated areas.	Loss estimations are included within each hazard profile. The methodology used for the various hazard assessments are included both in the general overview and within the hazard profiles.
Requirement §201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	Land use categories were noted in each of the jurisdictional regions by percentage.	Hazard profiles provide information with respect to land use and development trends, and the inclusion of the risk assessment information into future planning efforts. The capabilities matrix also provides information concerning integration of the risk assessment into other planning mechanisms, such as GMA, IBC, etc.

TABLE 2-1.
PLAN CHANGES CROSSWALK

44 CFR Requirement	2006 Plan	Plan Update
§201.6(c)(3): The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.	Potential losses were evaluated and mitigation initiatives were developed in response to both the likelihood and impact of specific hazard occurrence	The capabilities matrix defines the existing authorities and capabilities in place within the county and its jurisdictions, and defines the inclusion of the risk data as it relates to other planning initiatives throughout the county.
Requirement §201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	The plan includes 9 goals and several corresponding objectives, intended to be implemented by the communities by 2025	Goals and objectives were consolidated for improved plan readability.
Requirement §201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	The plan includes mitigation initiatives in several categories to include public education, structural retrofitting, land use development regulations, and plan implementation. Each proposed mitigation initiative shares a rationale describing its importance in terms of the hazard(s) addressed by the initiative.	The plan includes mitigation initiatives in several categories. Planning partners considered new and existing infrastructure in their mitigation strategy.
Requirement: §201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the National Flood Insurance Program, and continued compliance with the program's requirements, as appropriate.	The 2006 Plan identifies the jurisdictions county-wide participating in the NFIP.	The Flood profile includes information concerning the County and its jurisdictions' involvement in the NFIP, and relates insurance information, claim information and enrollment information.
Requirement: §201.6(c)(3)(iii): [The mitigation strategy shall describe] how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	Prioritization of mitigation actions were based on the jurisdiction specific hazard assessments. Reprioritization can take place between plan updates, following plan protocol. A cost-benefit analysis was conducted and ratio noted for each proposed mitigation action.	Planning partners base their decisions based on information collected through the risk assessment and prioritize based on maximum benefits.

TABLE 2-1.
PLAN CHANGES CROSSWALK

44 CFR Requirement	2006 Plan	Plan Update
Requirement §201.6(c)(4)(i): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	Plan maintenance section delineates a plan evaluation and update schedule with action steps to be taken within a five-year cycle	Plan maintenance section delineates a plan evaluation and update schedule with action steps to be taken within a five-year cycle
Requirement §201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	Plan maintenance section notes that jurisdictions will consider the impact of their mitigation initiatives when local plans such as capital facilities plans are reviewed	Each hazard profile discusses the integration of planning mechanisms throughout the county and their relationship and integration with the hazards of concern. The plan update takes into account other local and county-wide planning elements.
Requirement §201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.	The plan is available for review on the Grant County Department of Emergency Management webpage. Copies of the plan were sent to the County Planning Department and Building Department. Additionally, when an entity reprioritizes mitigation actions, that entity may utilize its own protocol for public notification and involvement.	The public involvement strategy is included in the plan maintenance process. The plan will be available for review through the Grant County Department of Emergency Management webpage, periodic press releases, via printed or disc copies to public libraries and through Local Emergency Planning Committee meetings and events.
Requirement §201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commissioner, Tribal Council).	Grant County, special purpose districts, and municipalities adopting the plan are listed in the Plan Adoption section with corresponding adoption resolution numbers.	Documentation of plan adoption is included in Volume 1, Appendix D upon plan approval.

CHAPTER 3.
PLAN METHODOLOGY

To develop the Grant County Hazard Mitigation Plan Update, the County followed a process that had the following primary objectives:

- Secure grant funding
- Form a planning team
- Establish a planning partnership
- Define the planning area
- Establish a steering committee
- Coordinate with other agencies
- Review existing programs
- Engage the public.

Chapter 4 describes the public involvement. The other objectives are discussed in the following sections.

3.1. GRANT FUNDING

This planning update was supplemented by a grant from Washington State Military Department, Emergency Management Division. Grant County Department of Emergency Management was the applicant agent for the grant. The grant started in 2009 and the contract was extended to May 31, 2013.

3.2. FORMATION OF THE PLANNING TEAM

Grant County hired Tetra Tech, Inc. to assist with development and implementation of the plan. The Tetra Tech project manager assumed the role of the lead planner, reporting directly to a County-designated project manager. A planning team was formed to lead the planning effort, made up of the following members:

- Bev O'Dea, Northwest Region Program Manager, Tetra Tech, Inc.
- Sandi Duffey, Project Manager, Grant County Emergency Management
- Sam Lorenz, Director (former), Grant County Emergency Management
- Joy Reese, Special Project Coordinator, Grant County Emergency Management

3.3. ESTABLISHMENT OF THE PLANNING PARTNERSHIP

Grant County opened this planning effort to all eligible local governments within the County. The planning team made a presentation at a stakeholder meeting on March 31, 2011 to introduce the mitigation plan update process, solicit planning partners, and begin the planning process. A follow-up to the initial stakeholder meeting was held on May 12, 2011 with potential planning partners. Key meeting objectives were as follows:

- Provide an overview of the Disaster Mitigation Act.
- Describe the reasons for a plan.

- Outline the County work plan.
- Outline planning partner expectations.
- Seek commitment to the planning partnership.
- Seek volunteers for the Steering Committee.

Each jurisdiction wishing to join the planning partnership was asked to provide a “letter of intent to participate” that designated a point of contact for the jurisdiction and confirmed the jurisdiction’s commitment to the process and understanding of expectations. Linkage procedures have been established (see Volume 2 of this plan) for any jurisdiction wishing to link to the Grant County plan in the future. The planning partners covered under this Plan are shown in Table 3-1.

TABLE 3-1.
COUNTY AND CITY PLANNING PARTNERS

Jurisdiction	Point of Contact	Title
Grant County	Sandi Duffey	EM Generalist
City of Ephrata	Jeremy Burns	Fire Chief
City of Moses Lake	Gilbert Alvarado	Community Development Director
City of Warden	Ron Curren	Director of Public Works
Fire Protection District #3	Anthony Leibelt	Assistant Chief
Fire Protection District #4	Randy Wiggins	Fire Chief
Fire Protection District #10	Brian Evans	Fire Chief
Fire Protection District #11	Brian Evans	Fire Chief
Fire Protection District #12	Scott Mortimer	Fire Chief
Quincy School District #144	Gus Winter	Security Coordinator

3.4. DEFINING THE PLANNING AREA

The planning area consists of all of Grant County. All partners to this plan have jurisdictional authority within this planning area.

3.5. THE STEERING COMMITTEE

Hazard mitigation planning enhances collaboration and support among diverse parties whose interests can be affected by hazard losses. A steering committee was formed to oversee all phases of the plan. The planning team assembled a list of candidates representing interests within the planning area that could have recommendations for the plan or be impacted by its recommendations. The partnership confirmed a committee of 10 members.

TABLE 3-2.
STEERING COMMITTEE MEMBERS

Name	Title	Jurisdiction/Agency	Representing
Ron Curren	Director of Public Works	City of Warden	City of Warden
Jeremy Burns	Fire Chief	Ephrata Fire Department	City of Ephrata
Gilbert Alvarado	Community Development Director	City of Moses Lake	City of Moses Lake
Anthony Leibelt	Assistant Fire Chief	Grant County Fire District #3	Grant County Fire District #3
Scott Mortimer	Fire Chief	Grant County Fire District #12	Grant County Fire District #12
Brian Evans	Fire Chief	Grant County Fire District #10	Grant County Fire District #10
Sam Lorenz	Director (former)	Grant County	Grant County Department of Emergency Management
Robert Schneider	Director (current)	Grant County	Grant County Department of Emergency Management
Sandi Duffey	Emergency Management Generalist	Grant County	Grant County Department of Emergency Management
Joy Reese	Emergency Management Special Project Coordinator	Grant County	Grant County Department of Emergency Management

Leadership roles and ground rules were established during the Steering Committee's initial meeting on May 12, 2011. The Steering Committee agreed to meet quarterly or as needed throughout the course of the plan's development. The planning team facilitated each Steering Committee meeting, which addressed a set of objectives based on the work plan established for the plan.

3.6. COORDINATION WITH OTHER AGENCIES

44CFR requires that opportunities for involvement in the planning process be provided to neighboring communities, local and regional agencies involved in hazard mitigation, agencies with authority to regulate development, businesses, academia, and other private and nonprofit interests (Section 201.6.b.2). This task was accomplished by the planning team as follows:

- **Steering Committee Involvement**—Agency representatives were invited to participate on the Steering Committee.
- **Agency Notification**—The following agencies were invited to participate in the plan development process from the beginning:

- Grant County Departments
- Incorporated Municipalities of Grant County
- Special Purpose Districts within Grant County (schools, fire, ports, etc.)
- Private sector representation

These agencies received meeting announcements, meeting agendas, and meeting minutes by e-mail throughout the plan development process. These agencies supported the effort by attending meetings or providing feedback on issues.

- **Pre-Adoption Review**—All the agencies listed above were provided an opportunity to review and comment on this plan, primarily through the Grant County Department of Emergency Management webpage (see Chapter 4). Each agency was sent an e-mail message informing them that draft portions of the plan were available for review. In addition, the complete draft plan was sent to the Washington State Military Department, Emergency Management Division for a pre-adoption review to ensure program compliance.

3.7. REVIEW OF EXISTING PROGRAMS

44CFR states that hazard mitigation planning must include review and incorporation, if appropriate, of existing plans, studies, reports and technical information (Section 201.6.b(3)). Volume 1, Chapter 9 of this plan provides a review of laws and ordinances in effect within the planning area that can affect hazard mitigation initiatives and in the jurisdictional annexes within Volume 2.

An assessment of all planning partners' regulatory, technical and financial capabilities to implement hazard mitigation initiatives is presented in the individual jurisdiction-specific annexes in Volume 2. Many of these relevant plans, studies and regulations are cited in the capability assessment.

3.8. PLAN DEVELOPMENT CHRONOLOGY/MILESTONES

Table 3-3 summarizes important milestones in the development of the plan.

TABLE 3-3. PLAN DEVELOPMENT MILESTONES		
Date	Event	Description
2009		
May	County submits grant application	Seek funding for plan development process
November	County receives notice of grant award	Funding secured.
2010		
May	County initiates contractor procurement	Seek a planning expert to facilitate the process.
2011		
January	County selects Tetra Tech to facilitate plan development	Facilitation contractor secured.
January	Planning team identified	Formation of the planning team.
March	Stakeholder meeting	Presentation on plan process given to potential planning partners.
March	Planning Partner Kickoff Meeting	Second meeting with potential planning partners. Attendees were advised of planning partner expectations and asked to formally commit to the process. Steering Committee volunteers were solicited.
March	Planning Partnership Finalized	Deadline for submittal of letters of intent to participate in the planning effort.
April	Steering Committee formed	Planning partners nominated potential committee members. The planning team received commitments from 14 members, finalizing the formation of the Steering Committee.
April	Steering Committee Meeting #1	Review current initiatives, discussion of plan format, review of hazard profiles, utilization of email survey.
September	Public Outreach	Webpage survey.
2012		
June	Plan Update Format	The format of the plan update was received from contractor and reviewed.
2013		
April	Public Review	Two public review meetings held.
April	Jurisdictional Annex Workshops	Mandatory session for planning partners. Workshops focused on how to complete the jurisdictional annex template via individual appointments with planning partners.
June	Draft Plan Review	Internal review draft provided by planning team to Steering Committee.
June	Public Comment Period	Via webpage.
June	Draft Plan Review	Draft plan submitted to Washington Military Department Emergency Management Division for review.
September	Plan revisions	Plan revised to reflect changes recommended by FEMA.
X/X	Adoption	Adoption pending approval
X/X	Plan Approval	Final plan approved by FEMA

CHAPTER 4.
PUBLIC INVOLVEMENT

Broad public participation in the planning process helps ensure that diverse points of view about the planning area's needs are considered and addressed. 44CFR requires that the public have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (Section 201.6.b.1). The Community Rating System expands on these requirements by making CRS credits available for optional public involvement activities.

4.1. STRATEGY

The strategy for involving the public in this plan emphasized the following elements:

- Use of a questionnaire to determine the public's perception via the Grant County Department of Emergency Management webpage.
- Attempt to reach as many planning area citizens as possible.
- Identify and involve planning area stakeholders.

4.1.1 Stakeholders and the Steering Committee

Stakeholders are the individuals, agencies and jurisdictions that have a vested interest in the recommendations of the hazard mitigation plan, including planning partners. The effort to include stakeholders in this process included stakeholder participation on the Steering Committee. The group had representation from special purpose districts, county departments and the local jurisdictions for Grant County.

4.1.2 Questionnaire

A hazard mitigation plan questionnaire was developed by the planning team with guidance from the Steering Committee. The questionnaire was used to gauge household preparedness for natural hazards and the level of knowledge of tools and techniques that assist in reducing risk and loss from natural hazards. This questionnaire was designed to help identify areas vulnerable to one or more natural hazards. A summary of its results can be found in Appendix B of this volume.

4.1.3 Opportunity for Public Comment

Public Meetings

Open-house public meetings were held on April 16, 2013 at Grant County Fire District #3 Station 1 and on April 23, 2013 at Big Bend Community College Hardin Room. The meetings notices were sent to the Grant County newspaper of record. The format allowed attendees to examine the plan, maps, and have direct conversations with project staff. Reasons for planning and information generated for the risk assessment were shared with attendees. Each attendee was given an opportunity to comment on the plan and talk about all-hazards in the County.

Internet

As part of the development process, the Grant county Department of Emergency Management webpage was utilized for part of the public review. This webpage will continue to be utilized for public access to this plan. The web page can be viewed at:

www.co.grant.wa.us/EM

4.2. PUBLIC INVOLVEMENT RESULTS

By engaging the public through the public involvement strategy, the concept of mitigation was introduced to the public, and the Steering Committee received feedback that was used in developing the components of the plan. Details of attendance and comments received are summarized in Table 4-1.

TABLE 4-1. SUMMARY OF PUBLIC MEETINGS

Date	Location	Number of Citizens in Attendance	Number of Comments Received
4/16/2013	Grant County Fire District #3 Main Station	5	2
4/23/13	Big Bend Community College	2	1
Total		**7**	**3**

CHAPTER 5.
GUIDING PRINCIPLE, GOALS AND OBJECTIVES

Hazard mitigation plans must identify goals for reducing long-term vulnerabilities to identified hazards (44CFR Section 201.6.c(3i)). The Steering Committee established a guiding principle, a set of goals and measurable objectives for this plan, based on data from the preliminary risk assessment and the results of the public involvement strategy. The guiding principle, goals, objectives and actions in this plan all support each other. Goals were selected to support the guiding principle. Objectives were selected that met multiple goals. Actions were prioritized based on the action meeting multiple objectives.

5.1. GUIDING PRINCIPLE

A guiding principle focuses the range of objectives and actions to be considered. This is not a goal because it does not describe a hazard mitigation outcome, and it is broader than a hazard-specific objective. The guiding principle for the Grant County Hazard Mitigation Plan Update is as follows:

> Through partnerships, reduce the vulnerability to natural hazards in order to protect the health, safety, welfare and economy of the communities within Grant County

5.2. GOALS

The following are the mitigation goals for this plan:

1. Protect life, property and the environment.
2. Continuously build and support local capacity to enable the public to mitigate, prepare for, respond to and recover from the impact of hazards and disasters.
3. Establish a hazard and disaster resilient economy.
4. Promote public awareness, engage public participation and enhance partnerships through education and outreach.
5. Encourage the development and implementation of long-term, cost-effective mitigation projects.

The effectiveness of a mitigation strategy is assessed by determining how well these goals are achieved.

5.3. OBJECTIVES

Each selected objective meets multiple goals, serving as a stand-alone measurement of the effectiveness of a mitigation action, rather than as a subset of a goal. The objectives also are used to help establish priorities. The objectives are as follows:

1. Reduce natural hazard-related risks and vulnerability to populations, critical facilities and infrastructure within the planning area.
2. Minimize the impacts of natural hazards on current and future land uses by encouraging use of incentives for hazard mitigation (i.e. NFIP, CRS).
3. Prevent or discourage new development in hazardous areas or ensure that if building occurs in high-risk areas it is done in such a way as to minimize risk.
4. Integrate hazard mitigation policies into land use plans within the planning area .

5. Update the plan annually to integrate local hazard mitigation plans and the results of disaster- and hazard-specific planning efforts.
6. Educate the public on the risk exposure to hazards and ways to increase the public's capability to prepare, respond, recover and mitigate the impacts of these events.
7. Utilize the best available data, science and technologies to improve understanding of the location and potential impacts of natural hazards, the vulnerability of building types, and community development patterns and the measures needed to protect life safety.
8. Retrofit, purchase, or relocate structures in high hazard areas including those known to be repetitively damaged.
9. Establish a partnership among all levels of government and the business community to improve and implement methods to protect property.
10. Encourage hazard mitigation measures that result in the least adverse effect on the natural environmental and that use natural processes.

CHAPTER 6.
PLAN ADOPTION

Section 201.6.c.5 of 44CFR requires documentation that a hazard mitigation plan has been formally adopted by the governing body of the jurisdiction requesting federal approval of the plan. For multi-jurisdictional plans, each jurisdiction requesting approval must document that it has been formally adopted. This plan will be submitted for a pre-adoption review to Washington Military Department, State Emergency Management Division and the State forwards the plan to the Federal Emergency Management Agency. Once pre-adoption approval has been provided, planning partners will formally adopt the plan. All partners understand that DMA compliance and its benefits cannot be achieved until the plan is adopted. Copies of the resolutions adopting this plan for all planning partners can be found in Appendix D of this volume.

CHAPTER 7.
PLAN MAINTENANCE STRATEGY

A hazard mitigation plan must present a plan maintenance process that includes the following (44CFR Section 201.6.c.4):

- A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan over a 5-year cycle.
- A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate.
- A discussion on how the community will continue public participation in the plan maintenance process.

This chapter details the formal process that will ensure that the Grant County Hazard Mitigation Plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. This chapter also describes how public participation will be integrated throughout the plan maintenance and implementation process. It also explains how the mitigation strategies outlined in this plan will be incorporated into existing planning mechanisms and programs, such as comprehensive land-use planning processes, capital improvement planning, and building code enforcement and implementation. The plan's format allows sections to be reviewed and updated when new data become available, resulting in a plan that will remain current and relevant.

7.1. PLAN IMPLEMENTATION

The effectiveness of the hazard mitigation plan depends on its implementation and incorporation of its action items into partner jurisdictions' existing plans, policies, and programs. Together, the action items in the Plan provide a framework for activities that the partnership can implement over the next 5 years. The planning team and the steering committee have established goals and objectives and have prioritized mitigation actions that will be implemented through existing plans, policies, and programs.

The Grant County Department of Emergency Management will have lead responsibility for overseeing the plan implementation and maintenance strategy. Plan implementation and evaluation will be a shared responsibility among all planning partnership members and agencies.

7.2. STEERING COMMITTEE

The steering committee that oversaw the development of the plan made recommendations on key elements of the plan, including the maintenance strategy. The steering committee will remain a viable body involved in key elements of the plan maintenance strategy. The steering committee will include representation from each planning partner jurisdiction, as well as other stakeholders in the planning area.

The principal role of the steering committee in this plan maintenance strategy will be to annually review the plan, the annual progress reports and provide input to Grant County Department of Emergency Management on possible enhancements. Future plan updates will be overseen by the steering committee. Completion of the individual progress reports are the responsibility of each planning partner. The steering committee will review the progress reports in an effort to identify issues needing to be addressed by future plan updates.

7.3. ANNUAL PROGRESS REPORT

The minimum task of each planning partner will be the evaluation of the progress of its individual mitigation initiatives during a 12-month period. This review will include the following:

- Summary of any hazard events that occurred during the performance period and the impact these events had on the planning area.
- Review of mitigation success stories.
- Review of continuing public involvement.
- Brief discussion about why targeted strategies were not completed.
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term one because of new funding).
- Recommendations for new projects.
- Changes in or potential for new funding options such as grant opportunities.
- Impact of any other planning programs or initiatives that involve hazard mitigation.

The Steering Committee has created a template to guide the planning partners in preparing a progress report (see Appendix C). The Steering Committee will report on the progress of the plan. This report should be used as follows:

- Posted on the Grant County Department of Emergency Management webpage
- Presented to planning partner governing bodies to inform them of progress.
- For those planning partners that participate in the Community Rating System, the report can be provided as part of the CRS annual re-certification package. The CRS requires an annual recertification to be submitted by October 1 of every calendar year for which the community has not received a formal audit.

Uses of the progress report will be at the discretion of each planning partner. Annual progress reporting is not a requirement specified under 44CFR. However, it may enhance the planning partnership's opportunities for funding. While failure to implement this component of the plan maintenance strategy will not jeopardize a planning partner's compliance under the Disaster Mitigation Act, it may jeopardize its opportunity to partner and leverage funding opportunities with the other partners. Each planning partner was informed of these protocols at the beginning of this planning process (in the "Planning Partner Expectations" package provided at the start of the process), and each partner acknowledged these expectations when with submittal of a letter of intent to participate in this process.

7.4. PLAN UPDATE

44CFR requires that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits under the Disaster Mitigation Act (Section 201.6.d.3). The Grant County partnership intends to update the hazard mitigation plan on a 5-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than 5 years based on the following triggers:

- A Presidential Disaster Declaration that impacts the planning area.

- A hazard event that causes loss of life.
- A comprehensive update of the County or participating city's comprehensive plan.

It will not be the intent of future updates to develop a complete new hazard mitigation plan for the planning area. The update will, at a minimum, include the following elements:

- The update process will be convened through a steering committee.
- The hazard risk assessment will be reviewed and if necessary, updated using best available information and technologies.
- The mitigation initiatives will be reviewed and revised to account for actions completed, removed, replaced, or updated and to account for changes in the risk assessment or new partnership policies identified under other planning mechanisms (such as the comprehensive plan).
- The draft update will be sent to planning partners and organizations for comment.
- The public will be given an opportunity to comment on the update prior to adoption.

The partnership governing bodies will adopt the updated plan.

7.5. CONTINUING PUBLIC INVOLVEMENT

The public will continue to be apprised of the plan's progress through the Grant County Department of Emergency Management webpage and press releases. Copies of the plan will be distributed to public libraries in Grant County. Upon initiation of future update processes, a new public involvement strategy will be initiated based on guidance from a new steering committee. This strategy will be based on the needs and capabilities of the planning partnership at the time of the update.

7.6. INCORPORATION INTO OTHER PLANNING MECHANISMS

The information on hazard, risk, vulnerability, and mitigation contained in this plan is based on the best science and technology available at the time this plan was prepared. The Grant County Comprehensive Plan and the comprehensive plans of the partner cities are considered to be integral parts of this plan. The County and partner cities, through adoption of comprehensive plans and zoning ordinances, have planned for the impact of natural hazards. The plan development process provided the County and the cities with the opportunity to review and expand on policies contained within these planning mechanisms. The planning partners used their comprehensive plans and the hazard mitigation plan as complementary documents that work together to achieve the goal of reducing risk exposure to the citizens of the Grant County. An update to a comprehensive plan may trigger an update to the hazard mitigation plan.

All municipal planning partners are committed to coordinate their own individual comprehensive plans with the hazard mitigation plan. Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Partners' emergency response plans.
- Capital improvement programs.
- Municipal codes.
- Community design guidelines.
- Water-efficient landscape design guidelines.
- Stormwater management programs.

- Water system vulnerability assessments.
- Master fire protection plans.

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. As information becomes available from other planning mechanisms that can enhance this plan, that information will be incorporated via the update process.

Further research is needed in evaluating and updating the risk posed by technological hazards in Grant County. The Grant County Department of Emergency Management plans to review and update technological hazard profiles to include in the next update. Due to the potential for technological hazards in the county, it was discovered that there is a need for very comprehensive assessment of these hazards. This is an ongoing process of local emergency management.

CHAPTER 8.
IDENTIFIED HAZARDS OF CONCERN AND EVALUATION METHODOLOGY

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from natural hazards. It allows emergency management personnel to establish early response priorities by identifying potential hazards and vulnerable assets. The process focuses on the following elements:

- Hazard identification—Use all available information to determine what types of disasters may affect a jurisdiction, how often they can occur, and their potential severity.
- Vulnerability identification—Determine the impact of natural hazard events on the people, property, environment, economy, and lands of the region.
- Cost evaluation—Estimate the cost of potential damage or cost that can be avoided by mitigation.

The risk assessment for this hazard mitigation plan update evaluates the risk of natural hazards prevalent in Grant County and meets requirements of the DMA (44 CFR, Section 201.6(c)(2)).

8.1. IDENTIFIED HAZARDS OF CONCERN

For this plan, the Steering Committee considered the full range of natural hazards that could impact the planning area and then listed hazards that present the greatest concern. The process incorporated review of state and local hazard planning documents, as well as information on the frequency, magnitude and costs associated with hazards that have impacted or could impact the planning area. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, this plan addresses the following hazards of concern:

- Natural hazards:
  - Dam failure
  - Drought
  - Earthquake
  - Flood
  - Landslide
  - Severe winter storms
  - Volcano
  - Wildfire
- Technological hazards (reserved for future plan update):
  - Hazardous materials
  - Pipeline
  - Public Health
  - Radiological incidents

- Terrorism

This hazard mitigation plan update addresses climate change as a secondary impact for some identified hazards. Those hazard chapters include a section with a qualitative discussion on the probable impacts of climate change for that hazard. While many models are currently being developed to assess the potential impacts of climate change, there are currently none available to support hazard mitigation planning. As these models are developed in the future, this risk assessment may be enhanced to better measure these impacts.

8.2. METHODOLOGY OVERVIEW

8.2.1 Natural Hazards

The risk assessments in Chapter 10 through Chapter 17 describe the risks associated with each identified natural hazard of concern. Each chapter describes the hazard, the planning area's vulnerabilities, and probable event scenarios. The following steps were used to define the risk of each hazard:

- Identify and profile each hazard—The following information is given for each hazard:
  - Geographic areas most affected by the hazard
  - Event frequency estimates
  - Severity estimates
  - Warning time likely to be available for response
- Determine exposure to each hazard—Exposure was determined by overlaying hazard maps with an inventory of structures, facilities, and systems to determine which of them would be exposed to each hazard.
- Assess the vulnerability of exposed facilities—Vulnerability of exposed structures and infrastructure was determined by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and FEMA's hazard-modeling program called HAZUS-MH were used to perform this assessment for the flood, dam failure and earthquake hazards.

8.2.2 Technological Hazards

Technological hazards are not included in this plan update. Technological hazards in Grant County will continue to be evaluated as a component of county-wide emergency management planning. The technological hazards will be assessed between plan update cycles.

8.3. RISK ASSESSMENT TOOLS FOR NATURAL HAZARDS

8.3.1 Dam Failure, Earthquake and Flood—HAZUS-MH

Overview

In 1997, FEMA developed the standardized Hazards U.S., or HAZUS, model to estimate losses caused by earthquakes and identify areas that face the highest risk and potential for loss. HAZUS was later expanded into a multi-hazard methodology, HAZUS-MH, with new models for estimating potential losses from hurricanes and floods.

HAZUS-MH is a GIS-based software program used to support risk assessments, mitigation planning, and emergency planning, and response. It provides a wide range of inventory data, such as demographics, building stock, critical facilities, transportation, and utility lifelines, and multiple models to estimate potential losses from natural disasters. The program maps and displays hazard data, and the results of damage and economic loss estimates for buildings and infrastructure. Its advantages include the following:

- Provides a consistent methodology for assessing risk across geographic and political entities.
- Provides a way to save data so that it can readily be updated as population, inventory, and other factors change and as mitigation planning efforts evolve.
- Facilitates the review of mitigation plans because it helps to ensure that FEMA methodologies are incorporated.
- Supports grant applications by calculating benefits using FEMA definitions and terminology.
- Produces hazard data and loss estimates that can be used in communication with local stakeholders.
- Is administered by the local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

The version used for this plan was HAZUS-MH 2.0, released by FEMA in July 2011.

Levels of Detail for Evaluation

HAZUS-MH provides default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. The model can carry out three levels of analysis, depending on the format and level of detail of information about the planning area:

- **Level 1**—All of the information needed to produce an estimate of losses is included in the software's default data. This data is derived from national databases and describes in general terms the characteristic parameters of the planning area.
- **Level 2**—More accurate estimates of losses require more detailed information about the planning area. To produce Level 2 estimates of losses, detailed information is required about local geology, hydrology, hydraulics, and building inventory, as well as data about utilities and critical facilities. This information is needed in a GIS format.
- **Level 3—**This level of analysis generates the most accurate estimate of losses. It requires detailed engineering and geotechnical information to customize it for the planning area.

Application for This Plan

The following methods were used to assess specific hazards for this plan:

- **Flood**—A Level 2, general building stock analysis was performed. GIS building and assessor data (replacement cost values and detailed structure information) were loaded into HAZUS-MH. An updated inventory was used in place of the HAZUS-MH defaults for essential facilities, transportation and utilities. Current Grant County DFIRMs were used to delineate flood hazard areas and estimate potential losses from the 100-year flood event. Using the DFIRM floodplain boundaries and a countywide digital elevation model (DEM), a flood depth grid was generated and integrated into the model.

- **Dam Failure—**Dam failure inundation mapping for Grant County was not available.
- **Earthquake**—A Level 2 analysis was performed to assess earthquake risk and exposure. Earthquake shake maps and probabilistic data prepared by the U.S. Geological Survey (USGS) were used for the analysis of this hazard. An updated general building stock inventory was developed using replacement cost values and detailed structure information from assessor tables. An updated inventory of essential facilities, transportation, and utility features was used in place of the HAZUS-MH defaults. Washington Department of Natural Resources National Earthquake Hazard Reduction Program (NEHRP) soils and Soils Liquefaction data was incorporated into the model. One scenario event and two probabilistic events were modeled:
  - The scenario event was a Magnitude-7.3 Saddle Mountain Fault event.
  - The standard HAZUS analysis for the 100- and 500-year probabilistic earthquake events was run.

8.3.2 Landslide, Severe Winter Storms, Volcano and Wildfire

For most of the hazards evaluated in this risk assessment, historical data was not adequate to model future losses. However, HAZUS-MH is able to map hazard areas, and calculate exposures if geographic information is available on the locations of the hazards and inventory data. Areas and inventory susceptible to some of the hazards of concern were mapped and exposure was evaluated. For other hazards, a qualitative analysis was conducted using the best available data and professional judgment. County-relevant information was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, emergency management specialists, and others. The primary data source was the Grant County GIS database, augmented with state and federal data sets. Additional data sources for specific hazards were as follows:

- **Landslide—**A dataset of steep slopes was generated using a 10 meter digital elevation model. Two slope classifications were created: 15 to 30 percent; and greater than 30 percent. Slope data was intersected with NEHRP Soils class D and E, described as soft soils.
- **Severe Winter Storms**—Severe weather data was downloaded from the Natural Resources Conservation Service and the National Climatic Data Center.
- **Volcano—**Volcanic hazard data was obtained from the USGS Cascade Volcano Observatory.
- **Wildfire—**Information on Wildfire Regime areas was provided by LandFire.

8.3.3 Drought

The risk assessment methodologies used for this plan focus on damage to structures. Because drought does not impact structures, the risk assessment for drought was more limited and qualitative than the assessment for the other hazards of concern.

8.3.4 Limitations

Loss estimates, exposure assessments and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

- Approximations and simplifications necessary to conduct a study.
- Incomplete or outdated inventory, demographic, and/or or economic parameter data.
- The unique nature, geographic extent, and severity of each hazard.
- Mitigation measures already employed.
- The amount of advance notice residents have to prepare for a specific hazard event.

These factors can affect loss estimates by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. The results do not predict precise results and should be used only to understand relative risk. Over the long term, Grant County and its planning partners will collect additional data to assist in estimating potential losses associated with other hazards.

CHAPTER 9.
GRANT COUNTY PROFILE

Grant County is located in central Washington (see

Figure 9-1). It is the 13th most populous county in the state. Its incorporated cities and towns are: Coulee City, Electric City, Ephrata, George, Grand Coulee, Hartline, Krupp, Mattawa, Moses Lake, Quincy, Royal City, Soap Lake, Warden and Wilson Creek. Ephrata, in the center of the county, is the county seat.

Figure 9-1. Main Features of Grant County

9.1. JURISDICTIONS AND ATTRACTIONS

Grant County is a rural county with a geographic area of 2,679 square miles, ranking 4th in size among Washington's 39 counties. The largest incorporated jurisdiction is the City of Moses Lake with a population of 20,950 (Washington State Office of Financial Management, 2012). Moses Lake is one of the state's largest natural fresh water lakes which attracts tourists for boating and water sports (Grant County Tourism, 2013). The nearby City of Warden is an agricultural community. To the north lies the incorporated jurisdictions of Coulee City, Electric City, Grand Coulee, Hartline, and Wilson Creek. These communities offer camping, boating, hunting, fishing and hiking. Grand Coulee Dam has a visitor's center and laser light show that brings in tourists during the summer months. This dam is the largest hydropower producer in the U.S. and is one of the largest concrete structures in the world. (U.S. Bureau of Reclamation, 2013). City of Ephrata is the county seat where the County Courthouse is located, with the City of Soap Lake a few miles away. The City of Quincy and Town of George are also agricultural communities, with the Crescent Bar recreation area just miles away. This recreation area along the Columbia River is set below basalt cliffs and has several condominium and resort buildings, attracting vacationers from across Washington State. The Gorge Amphitheatre draws in about 3,000 to 20,000 people per concert. The concerts are part of the area's local economy. The Quincy area is also home to several large data centers. The City of Royal City and Town of Mattawa to the south are agricultural communities nestled among orchards and vineyards.

There are some educational opportunities in Grant County, but large universities are located in Spokane, Pullman, and Seattle. Big Bend Community College near Moses Lake has an enrollment of 1,600 – 2,000 students annually. The college also houses two satellite campus programs, Heritage University and Central Washington University. There are several program options including the sciences, technology, education, flight, business, and the arts. (Big Bend Community College, 2013).

9.2. HISTORICAL OVERVIEW

Settlers first came to Grant County in the mid to late 1800's with plans of raising livestock, but the area was somewhat desolate. The county was officially created by Washington State Legislature in 1909, named after Ulysses S. Grant. The plans of raising livestock transitioned to dryland farming but irrigation would provide a wide range of benefits to the people. The creation of Grand Coulee Dam was approved in 1933 and completed in 1942. The Grand Coulee Dam is the cornerstone of the Columbia Basin Project, a multi-purpose project which now irrigates over 500,000 acres. Other benefits of the Columbia Basin Project are the electricity generated and waterways that provide miles of recreational activities within the area.

9.3. MAJOR PAST HAZARD EVENTS

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government, although no specific dollar loss threshold has been established for these declarations. A presidential disaster declaration puts federal recovery programs into motion to help disaster victims, businesses, and public entities. Some of the programs are matched by state programs. Grant County has experienced six events since 1957 for which presidential disaster declarations were issued. These events are listed in Table 9-1.

Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale events in the future. Still, many natural hazard events do not trigger federal disaster declaration protocol but have significant impacts on their communities. These events are also important to consider in establishing recurrence intervals for hazards of concern.

TABLE 9-1.
PRESIDENTIAL DISASTER DECLARATIONS FOR HAZARD EVENTS IN GRANT COUNTY

Type of Event	Disaster Declaration #	Date
Flood	70	March 1957
Flood	146	March 1963
Drought	(WA Declared) 3037	March 1977
Volcano	623	May 1980
Ice, Wind, Snow, Landslide and Flood	1159	December 1996-February 1997
Severe Winter Storm, Wind, Landslide, Mudslide	1682	December 2006

9.4. PHYSICAL SETTING

9.4.1 Geology

Grant County is in the Columbia Basin, an expansive area within eastern Washington, southwestern Idaho, and northern Oregon. It is characterized by basalt rocks, plateaus, and ridges. Between 17 and 6 million years ago, basaltic lava floods engulfed much of the Pacific Northwest. Approximately 15,000 years ago an ice dam gave way, causing flooding and the creation of channels through basalt rock. (Washington State Department of Natural Resources, 2013).

The topography in Grant County is variable, ranging from low rolling hills in the north to smooth, south-sloping plains in the south. The plains and hills are dissected by channeled scablands and coulees. Ground surface elevation ranges from 380 feet Mean Sea Level (MSL) at the south end of the County along the Columbia River to about 2,880 feet MSL at Monument Hill. The Grand Coulee, which contains Banks Lake, Park Lake, Blue Lake, Lake Lenore and Soap Lake, dissects the hills along the northwestern County line. The Columbia River flows along the southwestern and south boundaries of the County. The Beezley Hills, which are west of Ephrata and north of Quincy, trend generally east-west along the transition between the rolling hills and plains. The Frenchman Hills separate the plains south of Quincy and Royal Slope. Crab Creek lies between Royal Slope and the Saddle Mountains to the south. Wahluke Slope is bounded by the Saddle Mountains and the Columbia River. Evergreen Ridge, Babcock Bench and Babcock Ridge trend generally north-south along the east side of the Columbia River. (Grant County, 2006).

9.4.2 Soils

The U.S. Soil Conservation Service has generally characterized the surficial soils in Grant County as very shallow to very deep and well-drained to excessively drained. These soils are formed in glacial outwash, loess, lake deposits, and alluvial and colluvial deposits from rivers, streams, and surface water runoff. Soils on the outwash range from sandy loams to silty loams and generally are gravelly in profile. The glacial outwash and the alluvium along existing streams such as Crab Creek yield large quantities of water. Soils on lake beds are compacted, stratified silts. The loess and other windblown deposits range from sandy to silty. These soils erode easily. (Grant County, 2006).

9.4.3 Seismic Features

Some parts of Grant County have a moderate to high susceptibility to liquefaction including areas around Crab Creek, Soap Lake, Moses Lake, Wilson Creek, and Hartline. In an earthquake, strong ground shaking may cause soil in this area to lose strength and behave like quicksand. There are two fault lines in the county Frenchman Hills and Saddle Mountains Fault lines. Recent deformation has been documented along the Saddle Mountain fault. Evidence for quaternary faulting includes late Pleistocene to Holocene faulting along a graben adjacent to the Saddle Mountain fault, which suggests recent movement. A shallow-crustal quake in this area could be more damaging because the seismic waves are closer to the earth's surface than in a deeper earthquake. (FEMA, USGS, WA-DNR, WA-EMD 2012-2013). There are hanging wall tensional features in the Saddle Mountains anticline that probably cannot accommodate additional strain. The additional strain would likely induce a fault slip (Lidke, 2002).

9.4.4 Climate

Most of the air masses and weather systems crossing eastern Washington are traveling under the influence of the prevailing westerly winds. In the summer season, air from over the continent results in low relative humidity and high temperatures. In the winter, cold weather prevails. Extremes in temperature in both summer and winter occur when the inland basin is under the influence of air from over the continent. During most of the year, prevailing wind is from the west or southwest. Northeasterly winds are more frequent in fall and winter. Extreme wind velocities can be expected to reach 50 mph at least once in two years; 60 to 70 mph once in 50 years and 80 mph once in 100 years. (Grant County Hazard Mitigation Plan, 2006).

TABLE 9-2.
Climate Period of Record 2001 – 2008 Ephrata, WA

Temperature Type	January	April	July	October
Average Maximum Temperature	35.3	62.6	90.8	63.0
Average Minimum Temperature	23.2	36.8	61.8	39.0
Extreme Maximum Temperature	56	81	107	85
Extreme Minimum Temperature	-11	21	46	8
Precipitation	January	April	July	October
Average Monthly	.98	.45	.12	.53
Maximum Daily	.49	.58	.28	.92

Data Source: Western Regional Climate Center – Desert Research Institute – Reno, Nevada

The Columbia Basin is a semi-arid region with four distinct seasons. The land receives 8 to 11 inches of precipitation annually in the western and southern part, with about 1.0 to 1.5 inches of precipitation June through August. In winter, the maritime influence is strong due to prevailing westerly winds from the Pacific Ocean. Summer days are typically hot and dry. Extreme temperatures commonly exceed 100° F and reaching below 0° F in winter. (Grant County Comprehensive Plan, 2006).

9.5. CRITICAL FACILITIES AND INFRASTRUCTURE

Critical facilities and infrastructure are those that are essential to the health and welfare of the population. These become especially important after a hazard event. Critical facilities typically include police and fire stations, schools, and emergency operations centers. Critical infrastructure can include the roads and bridges that provide ingress and egress and allow emergency vehicles access to those in need, and the utilities that provide water, electricity, and communication services to the community. Also included are “Tier II” facilities, and railroads, which hold or carry significant amounts of hazardous materials with a potential to impact public health and welfare in a hazard event. As defined for this hazard mitigation plan update, critical facilities include but are not limited to the following:

- Police stations, fire stations, city/county government facilities (including those that house critical information technology and communication infrastructure), vehicle and equipment storage facilities, and emergency operations centers needed for disaster response before, during, and after hazard events

- Public and private utilities and infrastructure vital to maintaining or restoring normal services to areas damaged by hazard events. These facilities include but are not limited to:
  - Public and private water supply infrastructure, water and wastewater treatment facilities and infrastructure, potable water pumping, flow regulation, distribution and storage facilities and infrastructure.
  - Public and private power generation (electrical and non-electrical), regulation and distribution facilities and infrastructure.
  - Data and server communication facilities.
  - Structures that manage or limit the impacts of natural hazards such as regional flood conveyance systems, potable water trunk main interconnect systems, and redundant pipes crossing fault lines and reservoirs.
  - Major road and rail systems including bridges, airports, and marine terminal facilities.
- Educational facilities, including K-12, and community college.
- Community gathering places, such as libraries, community centers, senior centers, veteran's halls, and the County fairground.
- Hospitals, nursing homes, and housing likely to contain occupants who may not be sufficiently mobile to avoid death or injury during a hazard event.
- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic, and/or water-reactive materials.

Critical facilities within the cities participating in this plan are shown in maps for each city provided in Volume 2 of the plan. Due to the sensitivity of this information, a detailed list of facilities is not provided. The list is on file with each planning partner. Table 9-3 and 9-4 provide the general types of critical facilities and infrastructure, respectively, in each municipality and unincorporated county areas. All critical facilities/infrastructure were analyzed in HAZUS to help rank risk and identify mitigation actions. The risk assessment for each hazard qualitatively discusses critical facilities with regard to that hazard.

Table 9-3.
Grant County Critical Facilities Exposed to the Earthquake Hazard

City	Medical and Health	Government Functions	Protective Functions	Schools	Hazmat	Other Critical Functions	**Total**
Coulee City	0	0	2	2	0	0	**4**
Electric City	0	4	1	0	0	3	**8**
Ephrata	2	1	4	11	3	7	**28**
George	0	2	0	1	0	2	**5**
Grand Coulee	2	3	3	6	0	6	**20**
Hartline	0	1	1	1	0	1	**4**
Krupp	0	2	1	0	0	2	**5**

Mattawa	2	1	2	5	0	3	**13**
Moses Lake	5	36	3	11	5	23	**83**
Quincy	2	7	1	7	3	11	**31**
Royal City	1	4	1	3	0	7	**16**
Soap Lake	1	3	2	4	0	9	**19**
Warden	0	0	2	3	0	0	**5**
Wilson Creek	0	0	0	2	0	0	**2**
Unincorporated	0	6	22	23	10	50	**111**
Total	**15**	**70**	**45**	**79**	**21**	**124**	**354**

Table 9-4.
Grant County Critical Infrastructure Exposed to the Earthquake Hazard

City	Bridges	Water Supply	Wastewater	Power	Communications	Other	**Total**
Coulee City	0	0	0	1	0	0	**1**
Electric City	0	0	1	0	1	0	**2**
Ephrata	3	3	0	2	1	1	**10**
George	1	0	0	0	0	1	**2**
Grand Coulee	1	0	0	1	1	1	**4**
Hartline	0	0	0	0	0	0	**0**
Krupp	0	0	0	0	0	0	**0**
Mattawa	0	0	0	0	0	0	**0**
Moses Lake	10	5	2	0	2	1	**20**
Quincy	4	0	1	2	0	1	**8**
Royal City	0	1	0	1	1	0	**3**
Soap Lake	0	1	1	0	1	0	**3**
Warden	0	1	0	0	0	1	**2**
Wilson Creek	2	0	0	0	0	0	**2**
Unincorporated	251	2	2	7	15	28	**305**
Total	**272**	**13**	**7**	**14**	**22**	**34**	**362**

9.6. DEMOGRAPHICS

Some populations are at greater risk from hazard events because of decreased resources or physical abilities. Elderly people, for example, may be more likely to require additional assistance. Research has shown that people living near or below the poverty line, the elderly (especially older single men), the disabled, women, children, ethnic minorities and renters all experience, to some degree, more severe effects from disasters than the general population. These vulnerable populations may vary from the general population in risk perception, living conditions, access to information before, during and after a hazard event, capabilities during an event, and access to resources for post-disaster recovery. Indicators of vulnerability—such as disability, age, poverty, and minority race and ethnicity—often overlap spatially and often in the geographically most vulnerable locations. Detailed spatial analysis to locate areas where there are higher concentrations of vulnerable community members would assist the County in extending focused public outreach and education to these most vulnerable citizens.

9.6.1 Grant County Population Characteristics

Knowledge of the composition of the population and how it has changed in the past and how it may change in the future is needed for making informed decisions about the future. Information about population is a critical part of planning because it directly relates to land needs such as housing, industry, stores, public facilities, public services, and transportation. Grant County is the 13th largest of Washington's 39 counties. The U.S. Census estimated Grant County's population at 89,120 as of 2010. The County's largest city is Moses Lake, with an estimated 2009 population of 18,930. Ephrata, the county seat is the second most populated city with over 7,100 residents. According to the Office of Financial Management population estimates, over 47 percent of County residents live in unincorporated areas. Table 9-1 shows the population of incorporated municipalities and the combined unincorporated areas in Grant County.

Population changes are useful socio-economic indicators. A growing population generally indicates a growing economy, while a declining population signifies economic decline. In 2011, Grant County's estimated mid-year population was 90,100. Since 1981, the population has grown by 41,576. Grant County's annual rate of growth has ranged from 0.004% (1981) to a high of 5.02% (1995). For most of the period, Washington growth rates have rested below Grant County's. (www.grantcountytrends.ewu.edu). Table 9-5 shows the population of incorporated municipalities and the combined unincorporated areas in Grant County from 2004 through 2010.

TABLE 9-5.
CITY AND COUNTY POPULATION DATA

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Coulee City	605	600	600	600	600	600	600	565	560
Electric City	950	950	955	970	980	985	995	1,065	995
Ephrata	6,890	6,930	6,950	7,025	7,065	7,110	7,080	7,690	7,750
George	525	525	530	530	545	550	550	690	700
Grand Coulee	925	925	930	930	935	940	995	1,020	1,035
Hartline	135	135	135	145	145	145	145	150	150
Krupp	65	60	60	60	60	60	60	50	50
Mattawa	3,265	3,290	3,330	3,340	3350	3395	3,405	4,460	4,495
Moses Lake	16,110	16,340	16,830	17,440	18310	18930	19,460	20,640	20,950
Quincy	5,255	5,265	5,395	5,455	5700	6030	6,220	6,815	6,945
Royal City	1,815	1,870	1,875	1,885	1900	1865	2,050	2,150	2,160
Soap Lake	1,735	1,735	1,740	1,750	1765	1790	1,790	1,515	1,520
Warden	2,540	2,575	2,575	2,575	2600	2605	2,615	2,690	2,695
Wilson Creek	245	240	240	245	250	250	250	205	205
Unincorporated	37,240	37,660	38,455	39,550	40,395	40,845	41,485	40,395	40,790
Incorporated	41,060	41,440	42,145	42,950	44,205	45,255	46,215	49,705	50,210
Grant	78,300	79,100	80,600	82,500	84,600	86,100	87,700	**90,100**	**91,000**

Data Source: Washington State Office of Financial Management

9.6.2 Income

In the United States, individual households are expected to use private resources to prepare for, respond to and recover from disasters to some extent. This means that households living in poverty are automatically disadvantaged when confronting hazards. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in earthquakes and floods than other types of housing. In urban areas, the poor often live in older houses and apartment complexes, which are more likely to be made of un-reinforced masonry, a building type that is particularly susceptible to damage during earthquakes. Furthermore, residents below the poverty level are less likely to have insurance to compensate for losses incurred from natural disasters. This means that residents below the poverty level have a great deal to lose during an event and are the least prepared to deal with potential losses. The events following Hurricane Katrina in 2005 illustrated that personal household economics significantly impact people's decisions on evacuation. Individuals who cannot afford gas for their cars will likely decide not to evacuate.

Based on U.S. Census Bureau – American Community Survey (ACS) estimates for 2008, per capita income in Grant County was $19,205, and the median household income was $42,149 (in 2009 dollars, adjusted for inflation). It is estimated that there are 2053 households with less than $10,000 in income and benefits per year and 5879 households with $10,000 to $25,000 in income and benefits per year. About 28 percent of the households in Grant County make less than $25,000 per year and are therefore below the poverty level. As defined by the Office of Management and Budget and updated for inflation using the Consumer Price Index, the weighted average poverty threshold for a family of four in 2009 was $21,954; for a family of three, $17,098; for a family of two, $13,991; and for unrelated individuals, $10,956.

9.6.3 Age Distribution

As a group, the elderly are more apt to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences making recovery slower. They are more likely to be vision, hearing, and/or mobility impaired, and more likely to experience mental impairment or dementia. Additionally, the elderly are more likely to live in assisted-living facilities where emergency preparedness occurs at the discretion of facility operators. These facilities are typically identified as "critical facilities" by emergency managers because they require extra notice to implement evacuation. Elderly residents living in their own homes may have more difficulty evacuating their homes and could be stranded in dangerous situations. This population group is more likely to need special medical attention, which may not be readily available during natural disasters due to isolation caused by the event. Specific planning attention for the elderly is an important consideration given the current aging of the American population.

Children under 14 are particularly vulnerable to disaster events because of their young age and dependence on others for basic necessities. Very young children may additionally be vulnerable to injury or sickness; this vulnerability can be worsened during a natural disaster because they may not understand the measures that need to be taken to protect themselves from hazards.

The overall age distribution for Grant County is illustrated in Figure 9-2. According to U.S. Census ACS estimates for 2005-2009, 9,631, or 11.5 percent of Grant County's population is 65 or older. According to the 2005-2007 U.S. Census ACS data, 39.6 percent of the County's over-65 population has disabilities of some kind and 8.3 percent have incomes below the poverty line. Children under 18 account for 26 percent of individuals who are below the poverty line. It is estimated that 25.8 percent of the County's population is 14 or younger, slightly more than the state average of 21.3 percent. Figure 9-23 depicts poverty rates in Grant County based on age.

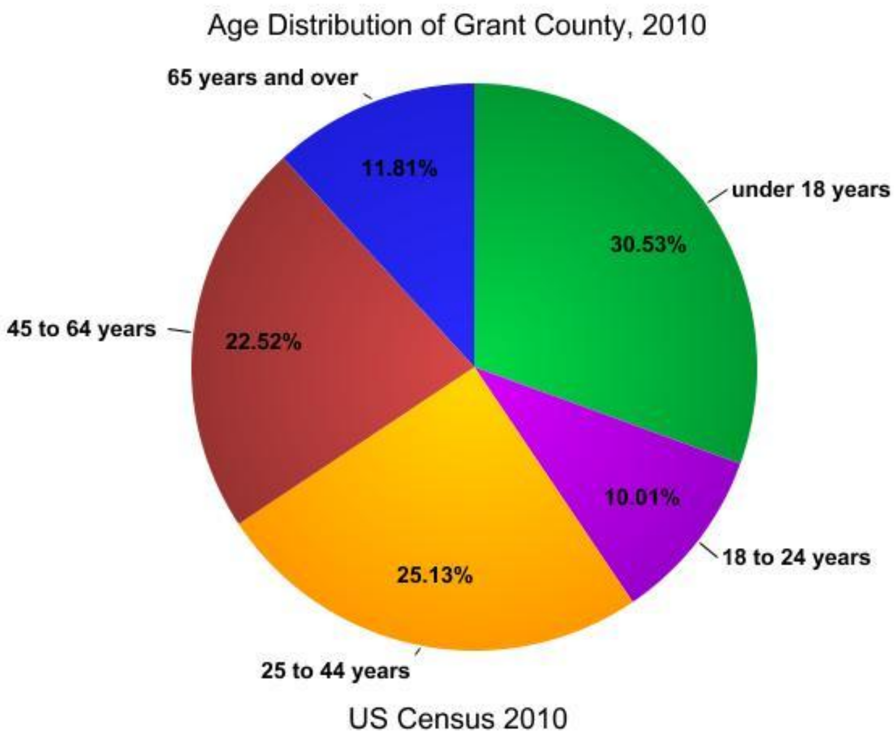


Figure 9-2. Grant County Age Distribution

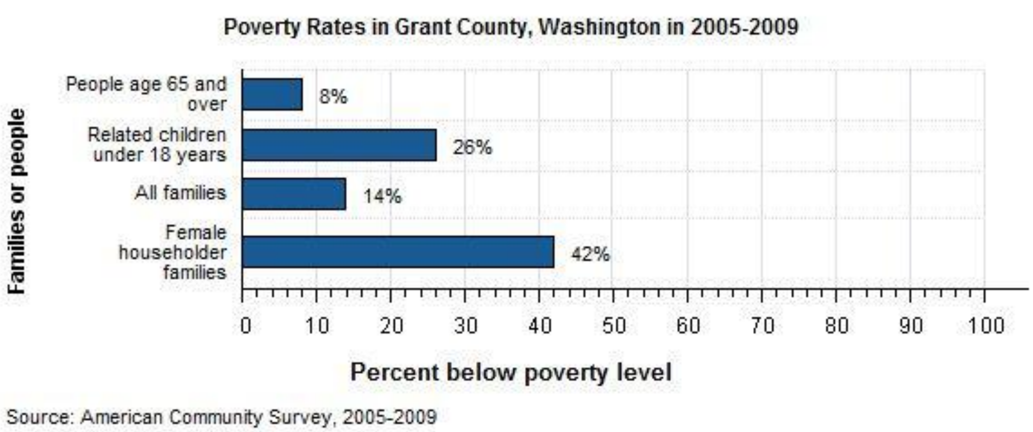


Figure 9-23. Grant County Poverty Rates

9.6.4 Race, Ethnicity and Language

Research shows that minorities are less likely to be involved in pre-disaster planning and experience higher mortality rates during a disaster event. Post-disaster recovery can be ineffective and is often characterized by cultural insensitivity. Since higher proportions of ethnic minorities live below the poverty line than the majority white population, poverty can compound vulnerability. According to the U.S. Census, the racial composition of Grant County is predominantly white, at about 72.8 percent. The largest minority population is Hispanic, at 38.3 percent of the total County population. Figure 9-4 shows the racial distribution of Grant County. Grant County has a 17.3 percent foreign-born population, with the majority born in Mexico.

Other than English, the most commonly spoken language in Grant County is Spanish with 28.3 percent of the population. The Census estimates that approximately 17 percent of the county's residents reported speaking English "less than very well."

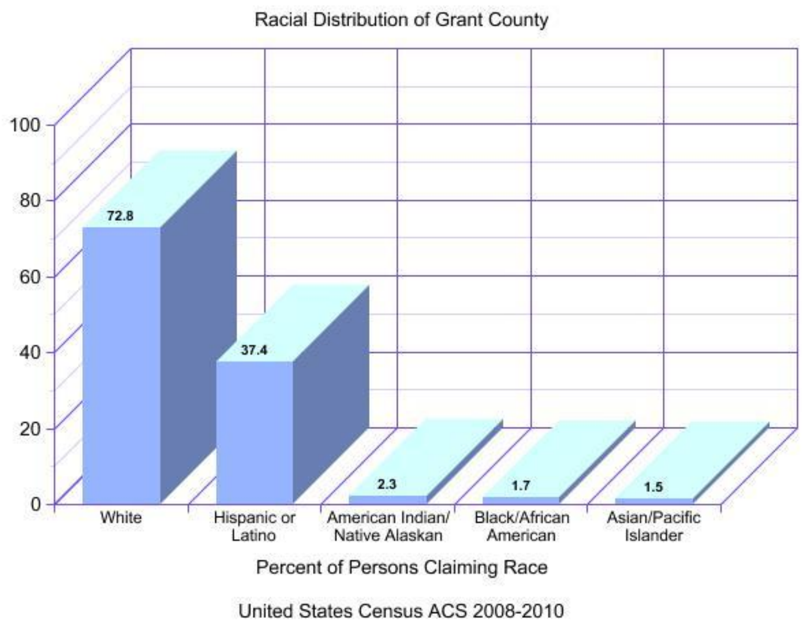


Figure 9-4 Grant County Race Distribution

People living with disabilities are significantly more likely to have difficulty responding to a hazard event than the general population. According to U.S. Census figures, roughly one-fifth of the U.S. population lives with a disability. Disabled populations are increasingly integrated into society. This means that a relatively large segment of the population will require assistance during the 72 hours after a hazard event, the period generally reserved for self-help. Disabilities can vary greatly in severity and permanence, making populations difficult to define and track. There is no "typical" disabled person, which can complicate disaster-planning processes that attempt to incorporate them. Disability is likely to be compounded with other vulnerabilities, such as age, economic disadvantage and ethnicity, all of which mean that housing is more likely to be substandard. While the percentage of disabled Grant County is virtually identical to the state as a whole (12.0% vs. 12.3%), the overall numbers are significant and warrant special attention from planners and emergency managers.

Table 9-6 summarizes the estimates of disabled people in Grant County. According to U.S. Census data, 12.3 percent of the County's population over the age of 5 has a disability.

TABLE 9-6.
DISABILITY STATUS OF NON-INSTITUTIONALIZED POPULATION

Age	Persons with a Disability	Percent of Age Group
Age 5 to 17 years	449	2.3
Age 18 to 64 years	4,258	8.4
Age 65 years and over	4,859	49.0

9.7. ECONOMY

9.7.1 Industry, Businesses and Institutions

According to GrantCountyTrends.ewu.edu, in 2010 the annual average unemployment rate for Grant County stood at 9.9%, higher than the 1990 rate of 8.5%. Unemployment for the state was 9.2% in 2010, which represents an 80% increase since 1990. The national unemployment rate has also increased, with a rate of 9.6% in 2010.During the graphing period, Grant County unemployment rates have consistently been higher than both the state and U.S. rates. However, since 2008, the unemployment rate gap has closed and Grant County is only slightly higher than the state and U.S. levels.

According to the 2009 Washington OFM Databook, the largest employment sector in Grant County is Agriculture, Forestry, Fishing and Hunting with 24.1 percent of total employment. Government services make up 21.1 percent, followed by manufacturing and wholesale/retail trade with 13.0 and 11.8 percent, respectively. Only about one percent of the industry in the County is involved with professional and technical services.

9.7.2 Employment Trends and Occupations

According to the American Community Survey, 67% of Grant County's population age 16 years and over is in the labor force. Of the population age group 20-64 years, 89% of males and 72% of females are in the labor force. Figure 9-5 compares Washington's and Grant County's unemployment trends from year 2002 through 2011. Grant County's unemployment rate was lowest in 2007 at 5.8 percent.

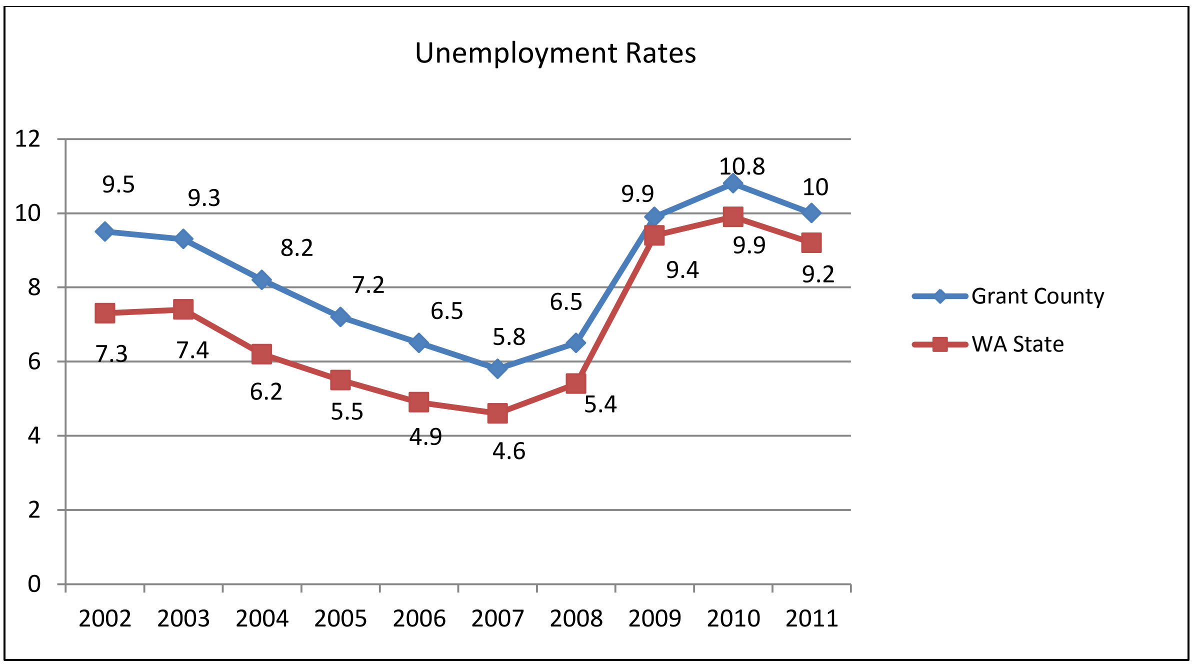


Figure 9-5. Washington and Grant County Unemployment Rate. Data source: WA State Employment Security Department

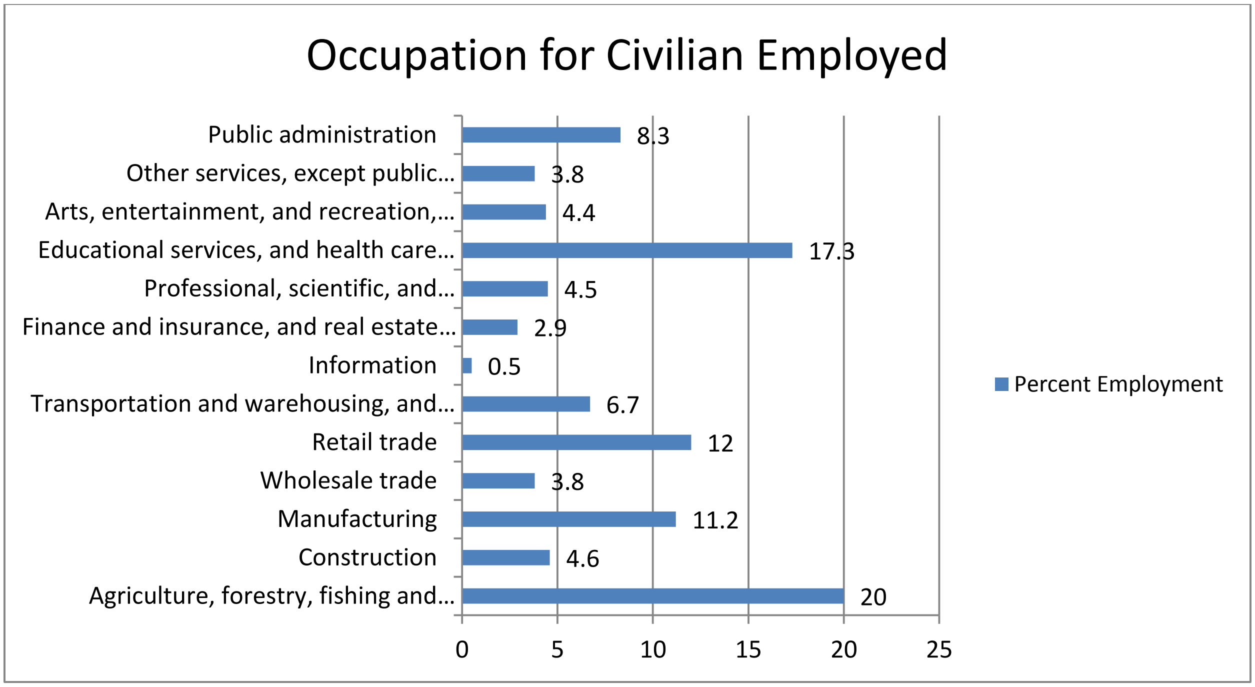


Figure 9-6 Occupations in Grant County. Data source: American Community Survey

Agriculture, forestry, fishing, hunting and mining make up 20 percent of the occupations in Grant County, followed by educational, health care and social assistance services at 17 percent. The largest employers in Grant County are the Moses Lake School District, Genie Industries, and REC Silicon. Workers in Grant County age 16 and over have an average commute time to work of 18.5 minutes. The state average commute time to work is 25.5 minutes. (American Community Survey, 2012).

9.8. FUTURE TRENDS IN DEVELOPMENT

The County and its cities have adopted comprehensive plans that govern land use decision and policy making their jurisdictions. Decisions on land use will be governed by these programs. This plan will work together with these programs to support wise land use in the future by providing vital information on the risk associated with natural hazards in Grant County.

All municipal planning partners will incorporate by reference the Grant County Hazard Mitigation Plan Update in their comprehensive plans. This will assure that all future trends in development can be established with the benefits of the information on risk and vulnerability to natural hazards identified in this plan.

9.9. LAWS AND ORDINANCES

Existing laws, ordinances, and plans at the federal, state, and local level can support or impact hazard mitigation initiatives identified in this plan. Hazard mitigation plans are required by 44CFR to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process (Section 201.6.b(3)). Pertinent federal and state laws are described below. Each planning partner has individually reviewed existing local plans, studies, reports, and technical information in its jurisdictional annex, presented in Volume 2.

9.9.1 Federal

Disaster Mitigation Act (DMA)

The DMA is the current federal legislation addressing hazard mitigation planning. It emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Grant Program funds are available to communities. This Plan is designed to meet the requirements of DMA, improving the planning partners' eligibility for future hazard mitigation funds.

Endangered Species Act

The federal Endangered Species Act (ESA) was enacted in 1973 to conserve species facing depletion or extinction and the ecosystems that support them. The act sets forth a process for determining which species are threatened and endangered and requires the conservation of the critical habitat in which those species live. The ESA provides broad protection for species of fish, wildlife, and plants that are listed as threatened or endangered. Provisions are made for listing species, as well as for recovery plans, and the designation of critical habitat for listed species. The ESA outlines procedures for federal agencies to follow when taking actions that may jeopardize listed species and contains exceptions and exemptions. It is the enabling legislation for the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Criminal and civil penalties are provided for violations of the ESA and the Convention.

Federal agencies must seek to conserve endangered and threatened species and use their authorities in furtherance of the ESA's purposes. The ESA defines three fundamental terms:

- **Endangered** means that a species of fish, animal or plant is "in danger of extinction throughout all or a significant portion of its range (for salmon and other vertebrate species, this may include subspecies and distinct population segments).
- **Threatened** means that a species "is likely to become endangered within the foreseeable future." Regulations may be less restrictive for threatened species than for endangered species.
- **Critical habitat** means "specific geographical areas that are…essential for the conservation and management of a listed species, whether occupied by the species or not."

Five sections of the ESA are of critical importance to understanding it:

- **Section 4: Listing of a Species**—The National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) is responsible for listing marine species; the U.S. Fish and Wildlife Service is responsible for listing terrestrial and freshwater aquatic species. The agencies may initiate reviews for listings, or citizens may petition for them. A listing must be made "solely on the basis of the best scientific and commercial data available." After a listing has been proposed, agencies receive comment and conduct further scientific reviews for 12 to 18 months, after which they must decide if the listing is warranted. Economic impacts cannot be considered in this decision, but it may include an evaluation of the adequacy of local and state protections. Critical habitat for the species may be designated at the time of listing.
- **Section 7: Consultation—**Federal agencies must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed or proposed species or adversely modify its critical habitat. This includes private and public actions that require a federal permit. Once a final listing is made,

non-federal actions are subject to the same review, termed a “consultation.” If the listing agency finds that an action will “take” a species, it must propose mitigations or “reasonable and prudent” alternatives to the action; if the proponent rejects these, the action cannot proceed.

- **Section 9: Prohibition of Take—**It is unlawful to “take” an endangered species, including killing or injuring it or modifying its habitat in a way that interferes with essential behavioral patterns, including breeding, feeding or sheltering.
- **Section 10: Permitted Take**—Through voluntary agreements with the federal government that provide protections to an endangered species, a non-federal applicant may commit a take that would otherwise be prohibited as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). These agreements often take the form of a “Habitat Conservation Plan.”
- **Section 11: Citizen Lawsuits**—Civil actions initiated by any citizen can require the listing agency to enforce the ESA’s prohibition of taking or to meet the requirements of the consultation process.

With the listing of salmon and trout species as threatened or endangered, the ESA has impacted most of the Pacific Coast states. Although some of these areas have been more impacted by the ESA than others due to the known presence of listed species, the entire region has been impacted by mandates, programs and policies based on the presumption of the presence of listed species.

The Clean Water Act

The federal Clean Water Act (CWA) employs regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation’s surface waters so that they can support “the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.”

Evolution of CWA programs over the last decade has included a shift from a program-by-program, source-by-source, pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach, equal emphasis is placed on protecting healthy waters and restoring impaired ones. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining water quality and other environmental goals is a hallmark of this approach.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) provides federally backed flood insurance in exchange for communities enacting floodplain regulations. Participation and good standing under NFIP are prerequisites to grant funding eligibility under the Robert T. Stafford Act. The County and most of the partner cities for this plan participate in the NFIP and have adopted regulations that meet the NFIP requirements.

9.9.2 State

Washington State Enhanced Mitigation Plan

The Washington State Enhanced Hazard Mitigation Plan was approved by the FEMA on October 1, 2010. It provides policy guidance for hazard mitigation throughout Washington. It identifies hazard mitigation goals, objectives, actions and initiatives for Washington state government that will reduce injury and damage from natural hazards. This plan meets federal requirements for an enhanced state plan (44 CFR parts 201.4 and 201.5). Meeting the federal requirements keeps the State of Washington and all eligible local jurisdictions and non-profit organizations that provide like-government services qualified to obtain disaster assistance including hazard mitigation grants. The enhanced portion of the plan allows the state to seek significantly higher funding for the Hazard Mitigation Grant Program following presidentially declared disasters (20 percent of federal disaster expenditures vs. 15 percent with a standard plan).

Growth Management Act

In 1990, the Washington State Legislature adopted the Growth Management Act (RCW Chapter 36.70A), which mandates that local jurisdictions adopt ordinances that classify, designate, and regulate land use in order to protect "critical areas." According to the code, critical areas include the following:

- Wetlands
- Areas with a critical recharging effect on aquifers used for potable water
- Fish and wildlife habitat conservation areas
- Frequently flooded areas
- Geologically hazardous areas.

Critical areas pertinent to this plan update include wetland areas and potential landslide areas as well as floodplains. The Growth Management Act regulates development in these areas, and therefore has the potential to affect hazard vulnerability and exposure at the local level. The Grant County Planning Department is in compliance and good standing with the provisions of the State growth management act as of this plan update process.

Shoreline Management Act

The Shoreline Management Act (RCW 90.58) was enacted in 1971 to manage and protect the shorelines of the state by regulating development in the shoreline area. A major goal of the act is to prevent the "inherent harm in an uncoordinated and piecemeal development of the state's shorelines." Its jurisdiction includes the Pacific Ocean shoreline and the shorelines of Puget Sound, the Strait of Juan de Fuca, and rivers, streams and lakes above a certain size. It also regulates wetlands associated with these shorelines.

Building Codes

The 2009 editions of the IBC include regulations for the Building, Residential, Mechanical and Fire. Likewise, the County must also comply with the 2009 Uniform Plumbing Code, published by the International Association of Plumbing and Mechanical Officials (IAPMO). In an effort to increase floodplain mitigation, FEMA, the Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE) and other organizations, developed minimum requirements for flood-resistant design and construction of buildings. These were integrated into previous editions of the I-Codes and met the minimum regulations for design and construction necessary for NFIP compliance. During 2009, an amendment in the IRC was created requiring freeboard above base flood elevation in single family homes as follows: "Buildings or structures in flood hazard areas not designated as Coastal A zones, shall have the lowest floor elevated to or above the design flood elevation, or a greater elevation as designated by local ordinance."

9.9.3 Cities and County

Each participating planning partner has prepared a jurisdiction-specific annex to this plan (see Volume 2). In preparing these annexes, each partner completed a capability assessment that looked at its regulatory, technical and financial capability to carry out proactive hazard mitigation.

Implementation through Existing Programs:
Local governments will retain responsibility for implementation of mitigation planning and activities. The Grant County All-Hazards Mitigation Plan is a multi-jurisdictional plan and the mechanism for implementation will be accomplished through existing programs now in place within Grant County and fourteen cities and towns; including the GMA (Growth Management Act).

Some existing programs which mitigate risks in Grant County are:

<u>Land Use Planning</u>
Each local government, county, city and town has an active land use management program. Whether supported by full or part time employment, each have addressed land use requirements under State law and developed actions for the Growth Management Act (GMA). It should also be noted that each program is coordinated in concept and activities through multiple capabilities. Cities and towns share and review land management practices through their association of cities and towns. Also, cities, towns and county, as developed in the GMA planning, coordinate proposed development activities through a comprehensive review process. These activities assure compliance to GMA and land use issues and also include mitigation practices. These practices include but are not limited to; (1) incorporating flood plain management in land use zoning and a development review process for compliance, (2) prohibition of construction within identified flood ways and flood way easements and, (3) restriction of building heights within airport runway conical zones.

<u>Building Code and Enforcement</u>
Building Code used in Grant County is based on the International Building Code (IBC) standards. The State of Washington has adopted the IBC and this is what gives Counties the requirements. These requirements are designed to provide safety for the public and emergency responders alike. It controls such things as occupancy, ceiling height, and building access and egress. It also controls construction in a flood plain which has a requirement that the structure meets the minimum standard of one foot above the flood way. New structures are also built to seismic hazard standards which may include seismic hold-downs on the structure or shear panels to provide protection from ground movement. In order to be in compliance, all new construction must be built to code. The Building Department inspects upgrades to existing structures and new construction for compliance. Sub-areas among the Building Code are Fire Code, Plumbing Code, Mechanical Code, and Residential Code. The Fire Code used is part of the Washington State Code that was developed in 1927. Fire and other codes are also designed to provide protection to the public.

<u>County Roads</u>
The Grant County Public Works Department follows the current structural design standards of the county for the development of new roads and other transportation structures such as bridges and culverts. The Road Engineer prepares these design standards which help to ensure public safety and compliance with sound engineering

practices. These are implemented through their appropriate guidelines including new construction and upgrades to existing structures to meeting current design standards. These design standards are provided in Resolution Number 85-52-CC. Construction of new structures shall be in compliance with the current edition of the Washington State Standard Specifications of Road, Bridge and Municipal Construction. Plans and special provisions are submitted to the County Road Engineer, who inspects all road construction projects. Any construction found to be deficient must be brought into compliance before final approval is given.

Public Health Programs

The Grant County Health District provides services for Environmental and Personal Health. Environmental Health Programs include: Chemical/Physical Hazards, Drinking Water and, Food Protection Programs. Personal Health Programs include: Immunization Services, Communicable Disease and, Child Care Programs among others. The Health District also provides Public Health Advisories which the Health Officer implements. The Health District provides public information through health fairs, attending public meetings and engaging in community outreach.

Special purpose districts also apply these same principles and/or participate in these programs. Many also have operational programs which are reviewed for operational planning and budgets annually.

To aid in the implementation, Grant County Emergency Management participates in land use management reviews for new projects; contacting new industry and businesses developing within the county or cities and towns. The review process provides a proactive approach to prompt developers to refer to codes, rules, and plans which attempt to control certain activities when proposed. These kinds of controls are for the most part understood by the public which allows for a simple and acceptable implementation process.

Another program process available is the capital facilities plan of specific functions and services adopted by jurisdictions in specific detail not covered in the comprehensive plan. This marks those major infrastructure developments or facilities which the entity has identified as needing within a six, ten, or twenty year plan. When the capital facilities plans are updated, jurisdictions will consider the impact of the mitigation initiatives they chose for this plan and their incorporation.

Other applicable plans/programs include:

- Grant County Comprehensive Emergency Management Plan
- Grant County Comprehensive Plan
- Washington State Enhanced Hazard Mitigation Plan

PART 2—NATURAL HAZARD PROFILES

CHAPTER 10.
DAM FAILURE

10.1. GENERAL BACKGROUND

10.1.1 Causes of Dam Failure

Dam failures in the United States typically occur in one of four ways (see Figure 10-1):

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
- Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

The remaining 6 percent of U.S. dam failures are due to miscellaneous causes. Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage. The most likely disaster-related causes of dam failure in Grant County are flood and sabotage. Presently Grant county maintains 5.53 percent of all dams within Washington, for a total of 64 dams.

DEFINITIONS

Dam—Any artificial barrier and/or any controlling works, together with appurtenant works, that can or does impound or divert water. (Washington Administrative Code, Title 173, Chapter 175.)

Dam Failure—An uncontrolled release of impounded water due to structural deficiencies in dam.

Emergency Action Plan—A document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize property damage and loss of life. The plan specifies actions the dam owner should take to alleviate problems at a dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show emergency management authorities the critical areas for action in case of an emergency. (FEMA 64)

High Hazard Dam—Dams where failure or operational error will probably cause loss of human life. (FEMA 333)

Significant Hazard Dam—Dams where failure or operational error will result in no probable loss of human life but can cause economic loss, environmental damage or disruption of lifeline facilities, or can impact other concerns. Significant hazard dams are often located in rural or agricultural areas but could be located in areas with population and significant infrastructure. (FEMA 333)

Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

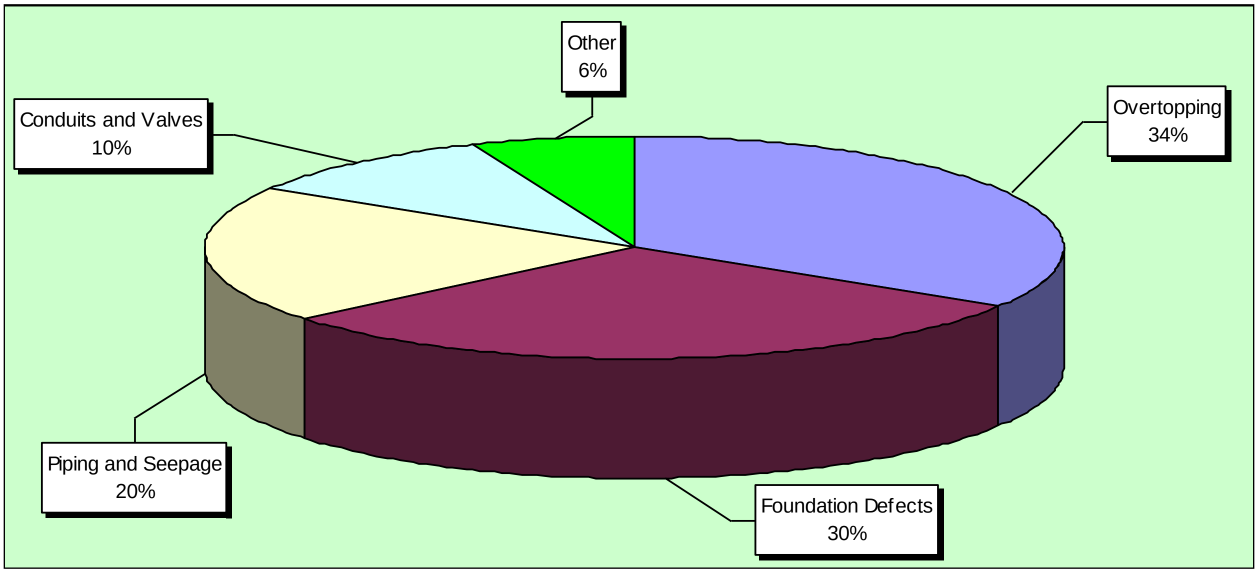


Figure 10-1. Historical Causes of Dam Failure

10.1.2 Regulatory Oversight

The potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program requires a periodic engineering analysis of every major dam in the country. The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect the lives and property of the public.

Washington Department of Ecology Dam Safety Guidelines

Under Washington State law, the Department of Ecology (Ecology) is responsible for regulating dams that capture and store at least 10 acre-feet (about 3.2 million gallons) of water or watery materials such as mine tailings, sewage and manure waste. The Department currently regulates nearly 1,157 water storage dams throughout the state. All statutory sized dams must be inspected by the Department. However, according to the Department of Ecology, with the current dam safety staffing, it is anticipated that high hazard dam inspections will occur on a 6-year cycle, while inspections on significant hazard dams will occur on a 12-year cycle. These inspection periods are longer than what federal dam safety guidelines recommend.

The first dam safety law in Washington was passed as part of the state water code in 1917 (RCW 90.03.350) This law required that engineering plans for any dam that could impound 10 or more acre-feet had to be reviewed and approved by the state before construction could begin. Over the years, the Department of Conservation and Development, then the Department of Water Resources performed this function. In 1970, responsibility transferred to the new Department of Ecology.

In Washington, besides regulating dams that meet the NID requirements, there are over 370 dams which do not meet one of the four criteria above, but do fall under the 10 acre-foot jurisdictional level. Ecology's Dam Safety Office currently oversees 996 of the 1,125 dams across the state. Through plan reviews and construction inspections, the agency helps ensure these facilities are properly designed and constructed. To reasonably secure the safety of human life and property, Ecology also conducts inspections of existing dams to assure proper operation and maintenance. The ages of dams in Washington vary from 11 dams constructed pre-1900, to more than 50 dams being completed since 2000. The age of a dam is also a factor in the stability, as many dams are constructed for a specified number of years, as well as the integrity of the materials used to construct the dam may deteriorate over time.

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers is responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. The Corps has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety (U.S. Army Corps of Engineers, 1997).

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) has the largest dam safety program in the United States. The FERC cooperates with a large number of federal and state agencies to ensure and promote dam safety and, more recently, homeland security. There are 3,036 dams that are part of regulated hydroelectric projects are in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC staff inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems.
- Complaints about constructing and operating a project.
- Safety concerns related to natural disasters.
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent consulting engineer, approved by the FERC, must inspect and evaluate projects with dams higher than 32.8 feet, or with a total storage capacity of more than 2,000 acre-feet.

FERC staff monitors and evaluates seismic research in geographic areas where there are concerns about seismic activity. This information is applied in investigating and performing structural analyses of hydroelectric projects in these areas. FERC staff also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC staff visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

The FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

10.2. HAZARD PROFILE

10.2.1 Past Events

Since 1918, 18 dam failures have occurred within Washington State, the latest occurring in 2010 in Snohomish County when a waste pond failed. The two most severe of these dam failures took the lives of 9 people total. The first incident occurred in 1932 near North Bend, when a slide caused water to back up,

1976 near Auburn when a surge in flow caused by increased discharge from Mud Mountain Dam and removal of flashboards at Diversion Dam killed two children playing in the White River. There have been three dam failures reported which have impacted Grant County. None of these dam failures are discussed on the Department of Ecology's current report for dam failures in Washington.

1. April 1956 - Timm Brother Dam at Coulee City on a Crab Creek Tributary failed after efforts to enlarge spillway were unsuccessful; the dam still remains shut down.
2. February 1957 - T. Claude Bennett Dam at Wilson Creek on Crab Creek failed when the spillway was unable to handle over-flow, causing flooding within the town of Wilson Creek.
3. July 1995 - CSC Orchard Dam failed, flooding one residence and one manufactured home.

Grant County has several major hydro-electrical structures along and within its borders which have the potential to impact the planning area, including: Priest Rapids, Pinto, Dryfalls and Wanapum Dams. Also up-river from the County Line are located Rock Island, Rocky Reach, Chief Joseph and Grand Coulee Dams. Grand Coulee Dam includes three hydroelectric plants, and currently is the largest concrete structure in the United States. Located within Grant County are several earth-filled dams which are holding facilities for irrigation reservoirs, such as: North Banks Lake Dam, Dry Falls Dam, Pinto Dam, and O'Sullivian Dam. There are also several smaller dams that are used as ponding devices for livestock, fish and gravel projects and fire protection reservoirs.

10.2.2 Location

According to Washington's Dam Safety Program, there are 64 dams in Grant County, as listed in Table 10-2. Of those, twelve (12) dams are operated by federal agencies, and the remainder are under the jurisdiction of the state or local jurisdiction, or privately owned.

10.2.3 Frequency

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides and excessive rainfall and snowmelt. There is a "residual risk" associated with dams. Residual risk is the risk that remains after safeguards have been implemented. For dams, the residual risk is associated with events beyond those that the facility was designed to withstand. However, the probability of any type of dam failure is low in today's regulatory and dam safety oversight environment.

10.2.4 Severity

Dam failure can be catastrophic to all life and property downstream. The Washington Dam Safety Program classifies dams and reservoirs in a three-tier hazard rating system (High, Significant and Low) based solely on the potential consequences to downstream life and property that would result from a failure of the dam and sudden release of water (Washington

State Department of Ecology Dam Safety Web Site, 2011). An alpha-numeric code is used as an index of potential consequences in the downstream valley if a dam were to fail and release the reservoir:

- **High Hazard**—A high-hazard means that if failure were to occur, the consequences likely would be a direct loss of human life and extensive property damage. All high-hazard dams must be properly designed and at all times responsibly maintained and operated. The Department of Ecology assigns three alpha-numeric codes to the High Hazard category with the following impact considered sufficient reason for assigning the high-hazard rating: 1A = Greater than 300 lives at risk; 1B= From 31-300 lives at risk; and 1C= From 7 to 30 lives at risk. An up-to-date Emergency Action Plan is a requirement for all owners of high-hazard dams.
- **Significant Hazard**—Significant hazard dams are those whose failure would result in significant risk. The alpha-numeric code assigned to this hazard class is 2= From 1 to 6 lives at risk.
- **Low Hazard**—Low hazard dams typically are located in sparsely populated areas that would be largely unaffected by a breach of the dam. Although the dam and appurtenant works may be totally destroyed, damages to downstream property would be restricted to undeveloped land with minimal impacts to existing infrastructure. The Department of Ecology assigns the alpha-numeric hazard rating of 3= No lives at risk.

The U.S. Army Corps of Engineers developed the classification system shown in Table 10-1 for the hazard potential of dam failures. The Corps of Engineers hazard rating system is based only on the potential consequences of a dam failure; neither system takes into account the probability of such failures.

TABLE 10-1.
CORPS OF ENGINEERS HAZARD POTENTIAL CLASSIFICATION

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss of life potential based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.
c. Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: U.S. Army Corps of Engineers, 1995

10.2.5 Warning Time

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be no warning time. A dam’s structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours (U.S. Army Corps of Engineers, 1997).

Grant County and its planning partners have established protocols for flood warning and response to imminent dam failure in the flood warning portion of its adopted emergency operations plan. These protocols are tied to the emergency action plans (EAPs) created by the dam owners.

10.3. SECONDARY HAZARDS

Dam failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards of dam failure are landslides around the reservoir perimeter, bank erosion on the rivers, and destruction of downstream habitat.

10.4. CLIMATE CHANGE IMPACTS

Dams are designed partly based on assumptions about a river’s flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream. Throughout the west, communities downstream of dams are already increases in stream flows from earlier releases from dams.

Dams are constructed with safety features known as “spillways.” Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as “design failures,” result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

10.4.1 Environment

Reservoirs held behind dams affect many ecological aspects of a river. River topography and dynamics depend on a wide range of flows, but rivers below dams often experience long periods of very stable flow conditions or saw-tooth flow patterns caused by releases followed by no releases. Water releases from dams usually contain very little suspended sediment; this can lead to scouring of river beds and banks.

The environment would be exposed to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways. This could result in destruction of downstream habitat and could have detrimental effects on many species of animals, especially endangered species such as salmon.

10.5. VULNERABILITY

10.5.1 Population

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable time frame. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television or radio emergency warning system.

10.5.2 Property

Vulnerable properties are those closest to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. This includes all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

10.5.3 Environment

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals, especially endangered species such as coho salmon. The extent of the vulnerability of the environment is the same as the exposure of the environment.

10.6. FUTURE TRENDS IN DEVELOPMENT

Land use in the planning area is be directed by land use plans adopted under Washington’s Growth Management Act and general planning laws specific to each jurisdiction. The safety elements of the general plans establish standards and plans for the protection of the community from hazards. The five major dams in Grant County are: Grant Coulee, Priest Rapids, Wanapum, Pinto and Dryfalls. Each dam has a Dam Safety Plan on file with the State and County. However, dam failure is currently not addressed as a standalone hazard in the safety elements of general response plans, but flooding is. The municipal planning partners have established comprehensive policies regarding sound land use in identified flood hazard areas. Most of the areas vulnerable to the more severe impacts from dam failure intersect the mapped flood hazard areas. Flood-related policies in the general plans will help to reduce the risk associated with the dam failure hazard for all future development in the planning area.

10.7. SCENARIO

An earthquake in the region could lead to liquefaction of soils around a dam. This could occur without warning during any time of the day. A human-caused failure such as a terrorist attack also could trigger a catastrophic failure of a dam that impacts the planning area. While the probability of dam failure is very low, the probability of flooding associated with changes to dam operational parameters in response to climate change is higher. Dam designs and operations are developed based on hydrographs with historical record. If these hydrographs experience significant changes over time due to the impacts of climate change, the design and operations may no longer be valid for the changed condition. This could have significant impacts on dams that provide flood control. Specified release rates and impound thresholds may have to be changed. This would result in increased discharges downstream of these facilities, thus increasing the probability and severity of flooding.

10.8. ISSUES

The most significant issue associated with dam failure involves the properties and populations in the inundation zones. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failure. These events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard. Important issues associated with dam failure hazards include the following:

- Federally regulated dams have an adequate level of oversight and sophistication in the development of emergency action plans for public notification in the unlikely event of failure. However, the protocol for notification of downstream citizens of imminent failure needs to be tied to local emergency response planning.
- Mapping for federally regulated dams is already required and available; however, mapping for non-federal-regulated dams that estimates inundation depths is needed to better assess the risk associated with dam failure from these facilities.
- Most dam failure mapping required at federal levels requires determination of the probable maximum flood. While the probable maximum flood represents a worst-case scenario, it is generally the event with the lowest probability of occurrence. For non-federal-regulated dams, mapping of dam failure scenarios that are less extreme than the probable maximum flood but have a higher probability of occurrence can be valuable to emergency managers and community officials downstream of these facilities. This type of mapping can illustrate areas potentially impacted by more frequent events to support emergency response and preparedness.
- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- Addressing security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.

TABLE 10-2
Grant County Dams

DAM NAME	SURFACE AREA ACRES	DAM NAME	SURFACE AREA ACRES
Alkali Lake	290	Merry Dam	140
Brown Dam No. 7	27,000	Moran Slough Dike	75
Carnation Waste Pond No. 5	6	Moses Lake North Dam	6,800
Carnation Waste Pond No. 6	5.2	Moses Lake South Dam	6,800
Carnation Waste Pond No. 7	20	Nestle Potato Effluent Lagoon	659
Chiawana Frenchman Hills Dam	2	O'Sullivan Dam	34,600
Clayton Michaels Wildlife Pond No 2-3	18	Othello Primary Treatment Pond 1A	115
Clayton Michaels Wildlife Pond No. 1	25	Othello Primary Treatment Pond 1B	115
Columbia Marsh Unit 1 Dam	68	Pacific NW Sugar Co Sedimentation Pond	48.7
Cougar Ranch Reservoir Lower Crab Creek	2.8	Pacific NW Sigar Co. Condensate & Flume Pond	-
Coulee City Dike	-	Pinto Dam	1,060
Coulee City Wastewater Lagoon	5.4	Port of Moses Lake Lagoon	-
Coulee City Wastewater Lagoon Cell 4	-	Priest Rapids Dam	8,320
CSC Orchards Reservoir	4.1	Quincy Aerated Lagoon No. 1	.9
Deep Lake Dam	970	Quincy Aerated Lagoon No. 2	.9
Dry Falls Dam and Powerplant	27,000	Quincy Chute Hydro Power Plant	1
Evans Desert Aire Pond	5.4	Quincy Industrial Wastewater Lagoon System	14
Evans Farm Unit 47 Pond	2.5	Rearing Pond Dike	48
Evans Farm Unit 50 Pond	2.4	REC Silicon Wastewater Pond	10
Evans Farm Unit 52 Pond	2.5	Rocky Ford Creek Dam	30
Evans Farm Unit 64 Pond	4	Simplot LRAR Lagoon	2.7
Evans Farm Unit 68 Pond	3.2	Smith Brothers Dairy Aeration Lagoon	-
City of George Wastewater Treatment Lagoon	6.6	Smith Brothers Dairy Freshwater Pond	-
Glyn Dam	6.3	Smith Brothers Dairy Storage Lagoon	12.9
Grand Coulee	82,300	Soda Lake Dike	180
Higginbotham Reservoir Dam	62	Summer Falls Hydro Power Plant	2.3
King Fuji Ranch Irrigation Reservoir	3.8	Sun Basin Ski Ranch Pond	10
Lawrence Orchards Dam	2.8	Wanapum Dam	14,720
Lenice Dam	94	Western Polymer Process Water Lagoon	4.7
Lindblad Brothers Dam	0	Zirkle Partridge Ranch Dam	2
Lower Goose Lake Dam	50	Zirkle Rockstrom Dam	2.8
McDonald Dam	200	Zirkle Royal Slope Dam	4
		Zirkle Soaring Eagle Dam	3

Washington State Dept. of Ecology 2013

CHAPTER 11.
DROUGHT

11.1. GENERAL BACKGROUND

DEFINITIONS

Drought—The cumulative impacts of several dry years on water users. It can include deficiencies in surface and subsurface water supplies and generally impacts health, well being, and quality of life.

Hydrological Drought—Deficiencies in surface and subsurface water supplies.

Socioeconomic Drought—Drought impacts on health, well being and quality of life.

Drought is a prolonged period of dryness severe enough to reduce soil moisture, water and snow levels below the minimum necessary for sustaining plant, animal and economic systems. Droughts are a natural part of the climate cycle. In the past century, Washington State has experienced a number of drought episodes, including several that lasted for more than a single season – 1928 to 1932, 1992 to 1994, and 1996 to 1997. Washington has a statutory definition of drought (Revised Code of Washington Chapter 43.83B.400). According to state law, an area is in a drought condition when:

- The water supply for the area is below 75 percent of normal.
- Water uses and users in the area will likely incur undue hardships because of the water shortage.

Drought can have a widespread impact on the environment and the economy, depending upon its severity, although it typically does not result in loss of life or damage to property, as do other natural disasters. The National Drought Mitigation Center uses three categories to describe likely drought impacts:

- Agricultural—Drought threatens crops that rely on natural precipitation.
- Water supply—Drought threatens supplies of water for irrigated crops and for communities.
- Fire hazard—Drought increases the threat of wildfires from dry conditions in forest and rangelands.

In Washington, where hydroelectric power plants generate nearly three-quarters of the electricity produced, drought also threatens the supply of electricity.

Unlike most disasters, droughts normally occur slowly but last a long time. Drought conditions occur every few years in Washington. The droughts of 1977 and 2001, the worst and second worst in state history, provide good examples of how drought can affect the state. On average, the nationwide annual impacts of drought are greater than the impacts of any other natural hazard. They are estimated to be between $6 billion and $8 billion annually in the United States and occur primarily in the agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts.

Drought affects groundwater sources, but generally not as quickly as surface water supplies, although groundwater supplies generally take longer to recover. Reduced precipitation during a drought means that groundwater supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. About 16,000 drinking water systems in Washington get water from the ground; these systems serve about 5.2 million people. Reduced replenishment of groundwater affects streams. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when steam flows are lowest.

A drought directly or indirectly impacts all people in affected areas. A drought can result in farmers not being able to plant crops or the failure of planted crops. This results in loss of work for farm workers and those in related food processing jobs. Other water- or electricity-dependent industries are commonly forced to shut down all or a portion of their facilities, resulting in further layoffs. A drought can harm recreational companies that use water (e.g., swimming pools, water parks, and river rafting companies) as well as landscape and nursery businesses because people will not invest in new plants if water is not available to sustain them. With much of Washington's energy coming from hydroelectric plants, a drought means less inexpensive electricity coming from dams and probably higher electric bills. All people could pay more for water if utilities increase their rates.

11.1.1 Probability of Future Occurrence

Empirical studies conducted over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature; these include global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation.

Scientists at this time do not know how to predict drought more than a month in advance for most locations. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. How long they last depends on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale.

In temperate regions, including Washington, current long-range forecasts of drought have limited reliability. In the tropics, empirical relationships have been demonstrated between precipitation and El Niño events, but few such relationships have been demonstrated above the 30º north latitude. Meteorologists do not believe that reliable forecasts are attainable at this time a season or more in advance for temperate regions.

Based on Washington's history with drought from 1895 to 1995, the state as a whole can expect severe or extreme drought at least 5 percent of the time in the future. All of Eastern Washington, except for the Cascade Mountain's eastern foothills, can expect severe or extreme drought 10 to 15 percent of the time. The east slopes of the Cascades can expect severe or extreme drought from 5 to 10 percent of the time.

11.2. HAZARD PROFILE

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is considered to be long-term. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

11.2.1 Past Events

In the past century, Washington State has experienced a number of drought episodes, including several that lasted for more than a single season – 1928 to 1932, 1992 to 1994, and 1996 to 1997. The droughts of 1977 and 2001 are the first and second worst droughts in state history, respectively.

- **June-August 1922 -** From June 10 to August 20, the statewide precipitation average was only .10 inches.
- **April 1934-March 1937 -** the longest drought in the region's history. The driest periods were April-August, 1934; September-December 1935; and July-January 1936-1937.
- **1977 Drought -** The cumulative impact led to widespread water shortages and severe water conservation measures throughout the state. Storms during the first three weeks of May 1977 resulted in slight increases to the amount of water in streams. Cool temperatures slowed the melting of mountain snow, causing stream flows to continue to decline. An estimated 70+ public and private drinking-water operations reported water-supply problems. Wheat and cattle were the most seriously affected agricultural products in Washington. The Federal Power Commission ordered public utilities on the Columbia River to release water to help fish survive. Dryland and irrigated agriculture experienced in excess of $400 million loss because of the drought conditions. The 1977 Drought resulted in Declaration Number WA3037.
- **2001 Drought** - On March 14, 2001, Gov. Gary Locke authorized the Department of Ecology (Ecology) to declare a statewide drought emergency. Unlike other natural disasters, droughts normally occur slowly but last a long time. By most standards, the 2001 drought came on fairly rapidly. Between November 2000 and March 2001, most of the state's rainfall and snowpack totals were only about 60 percent of normal. The 2001event was as a result of warm weather melting snow pack into streams a month earlier than normal, thus increasing the amount of water in streams earlier than normal. Nine large utility companies statewide advised the Washington State Department of Health that they were highly vulnerable to the drought. As a result of the 2001 drought, 90,000 acres of agricultural land were taken out of production; thousands of acres of orchards were unused, and the sugar beet industry was out of production.

While no Presidentially Declared drought situations have impacted Grant County as reported by FEMA or the Spatial Hazard Event Loss Data for United States (SHELDUS), Grant County has historically been impacted by the drought conditions occurring three or four times during any 10-year period. The farmers and ranchers experience economic failures that occur with the drought and the economic stability of the entire county is affected. Additionally, drought conditions within Grant County tend to breed pestilence, and the effects of the grasshoppers on irrigated land has historically become a major problem economically. The drought conditions also increase the demand for irrigation and begin to deplete underground aquifers as deep as 100 feet. Aquifers are important to the communities and families in Grant County as they provide water supplies and support the lives of the County's population.

Fire dangers, which are extremely high in the normal, dry seasons, become more and more hazardous in drought conditions. Loss of crops and much needed rangeland occurs and control of fires strain the budgets of all fire districts. This increases manpower and equipment use and equipment failure. Power supply is also affected by depletion of hydroelectric power water supplies in storage reservoirs.

11.2.2 Location

The National Oceanic and Atmospheric Administration (NOAA) has developed several indices to measure drought impacts and severity and to map their extent and locations:

- The ***Palmer Crop Moisture Index*** measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.
- The ***Palmer Z Index*** measures short-term drought on a monthly scale. Figure 11-1 shows this index for March 2011.
- The ***Palmer Drought Index (PDI)*** measures the duration and intensity of long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during a given month is dependent on the current weather patterns plus the cumulative patterns of previous months. Weather patterns can change quickly from a long-term drought pattern to a long-term wet pattern, and the PDI can respond fairly rapidly. Figure 11-2 shows this index for March 2011.
- The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The ***Palmer Hydrological Drought Index (PHDI)***, another long-term index, was developed to quantify hydrological effects. The PHDI responds more slowly to changing conditions than the PDSI. Figure 11-3 shows this index for March 2011.
- While the Palmer indices consider precipitation, evapotranspiration and runoff, the ***Standardized Precipitation Index (SPI)*** considers only precipitation. In the SPI, an index of zero indicates the median precipitation amount; the index is negative for drought and positive for wet conditions. The SPI is computed for time scales ranging from one month to 24 months. Figure 11-4 shows the 24-month SPI map for April 2009 through March 2011.

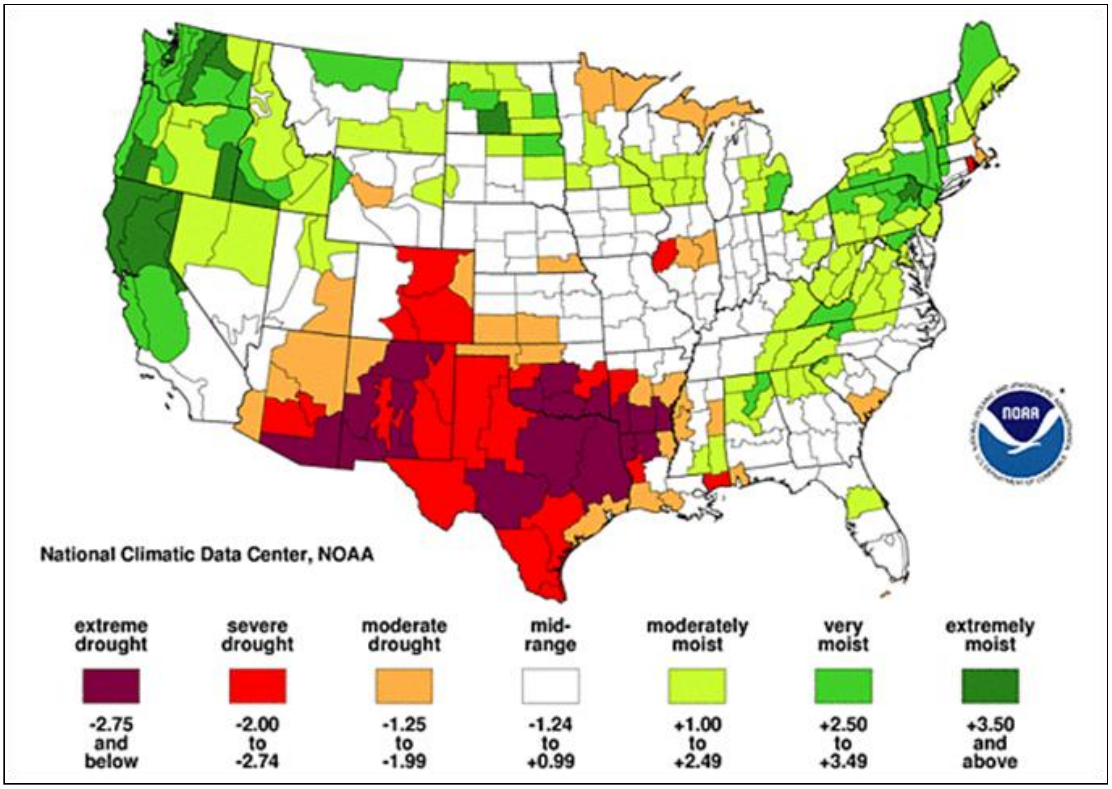


Figure 11-1. Palmer Z Index Short-Term Drought Conditions (March 2011)

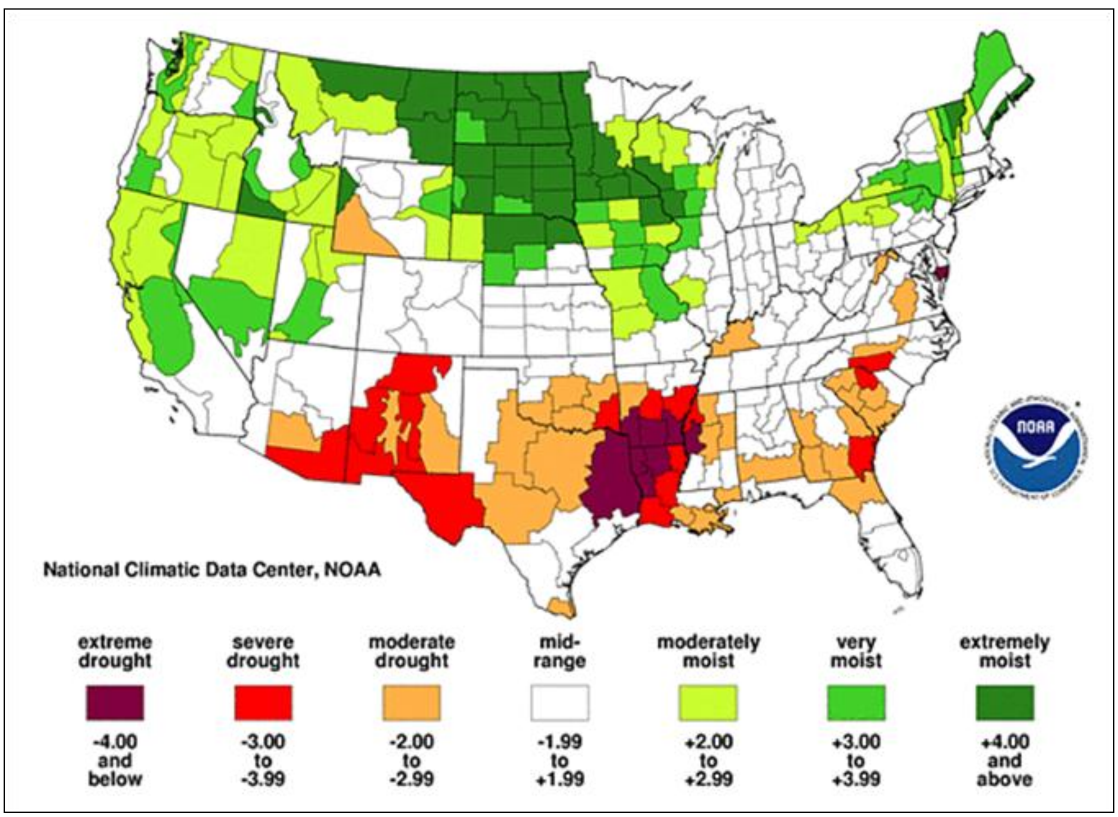


Figure 11-2. Palmer Drought Index Long-Term Drought Conditions (March 2011)

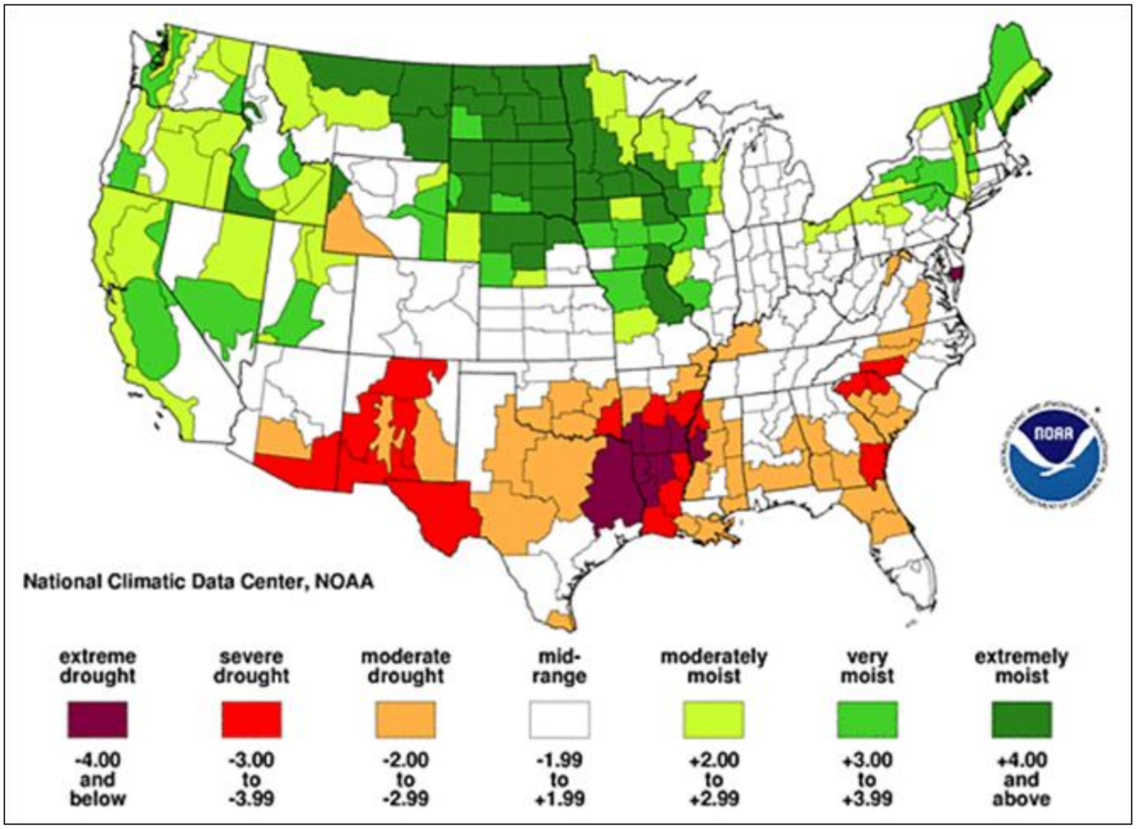


Figure 11-3. Palmer Hydrological Drought Index Long-Term Hydrologic Conditions (March 2011)

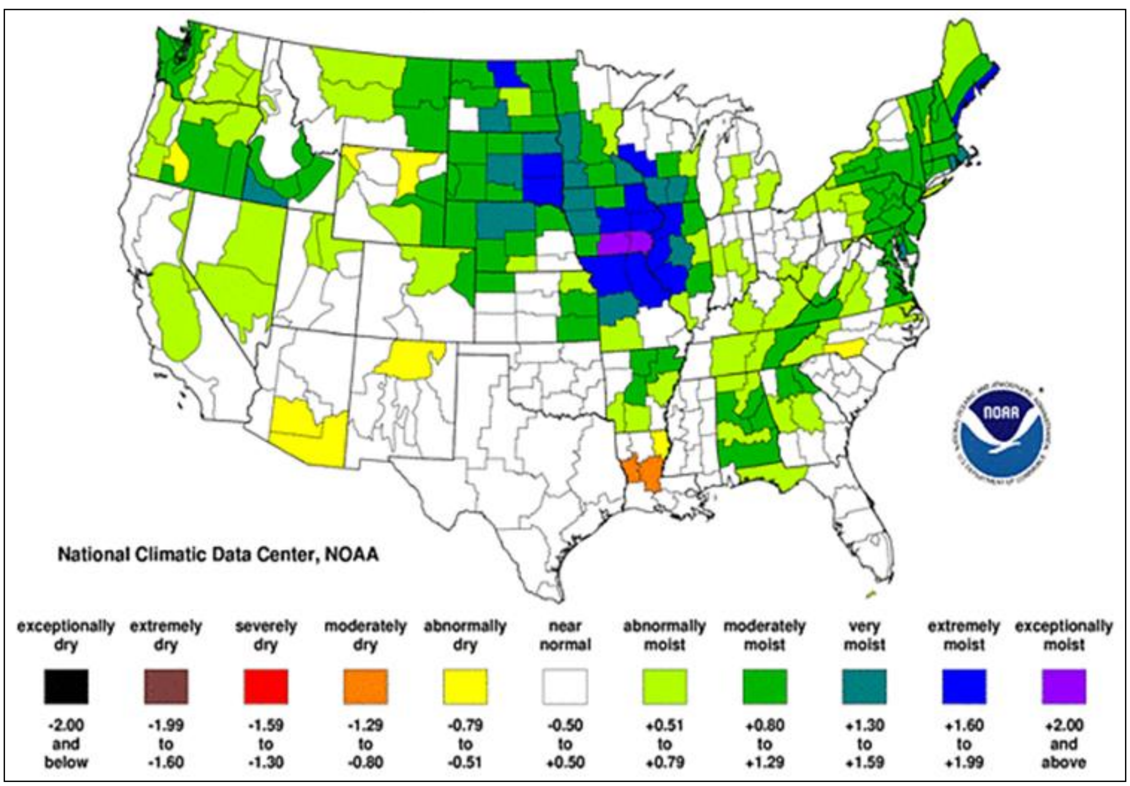


Figure 11-4. 24-Month Standardized Precipitation Index (April 2009—March 2011)

11.2.3 Frequency

The Washington State Hazard Mitigation Plan determined that from the period of 1895 to 1995, Grant County experienced serious or extreme drought at least 10-15% of the time. Thus it can be said that Grant County can experience the effects of drought at least once every decade.

11.2.4 Severity

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Droughts are not usually associated with direct impacts on people or property, but they can have significant impacts on agriculture, which can impact people indirectly. When measuring the severity of droughts, analysts typically look at economic impacts on a planning area.

11.2.5 Warning Time

Droughts are climatic patterns that occur over long periods of time. Only generalized warning can take place due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions.

11.3. SECONDARY HAZARDS

The secondary hazard most commonly associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends.

11.4. CLIMATE CHANGE IMPACTS

Research conducted by the Climate Impacts Group at the University of Washington indicates that the temperature of Eastern Washington is increasing. As temperatures increase there will be less water stored as ice and snow. This reduction may not result in a net change in annual precipitation, but it will result in lower late spring and summer river flows. Accordingly there will be increased competition between power, sport fishing and environmentalists, and farmers dependent on irritation.

The long-term effects of climate change on regional water resources are unknown, but global water resources are already experiencing the following stresses without climate change:

- Growing populations
- Increased competition for available water
- Poor water quality
- Environmental claims
- Uncertain reserved water rights
- Groundwater overdraft
- Aging urban water infrastructure

With a warmer climate, droughts could become more frequent, more severe, and longer-lasting. From 1987 to 1989, losses from drought in the U.S. totaled $39 billion (OTA, 1993). More frequent extreme events such as droughts could end up being more cause for concern than the long-term change in temperature and precipitation averages.

The best advice to water resource managers regarding climate change is to start addressing current stresses on water supplies and build flexibility and robustness into any system. Flexibility helps to ensure a quick response to changing conditions, and robustness helps people prepare for and survive the worst conditions. With this approach to planning, water system managers will be better able to adapt to the impacts of climate change.

11.5. EXPOSURE

All people, property and environments in the Grant County planning area would be exposed to some degree to the impacts of moderate to extreme drought conditions.

11.6. VULNERABILITY

Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to the ability to produce goods and provide services. Drought can affect a wide range of economic, environmental and social activities. The vulnerability of an activity to the effects of drought usually depends on its water demand, how the demand is met, and what water supplies are available to meet the demand.

The Washington State Hazard Mitigation plan defines counties as being vulnerable to drought if they meet at least five of the following criteria:

- History of severe or extreme drought conditions:
    1. The county must have been in serious or extreme drought at least 10-15 percent of the time from 1895 to 1995.
- Demand on water resources based on:
    2. Acreage of irrigated cropland. The acreage of the county’s irrigated cropland must be in top 20 in the state.
    3. Percentage of harvested cropland that is irrigated. The percentage of the county’s harvested cropland that is irrigated must be in top 20 in the state.
    4. Value of agricultural products. The value of the county’s crops must be in the top 20 in the state.
    5. Population growth greater than the state average. The county’s population growth from 2000 to 2006 must be greater than state average of 8.17 percent.
- A County’s inability to endure the economic conditions of a drought, based on:
    6. The county’s median household income being less than 75 percent of the state median income of $51,749 in 2005.
    7. The county being classified as economically distressed in 2005 because its unemployment rate was 20 percent greater than the state average from January 2002 through December 2004.

As summarized in Table 11-1, Grant County is among nine counties in the state that meet at least five of the criteria and are considered to be vulnerable to drought.

**TABLE 11-1.
GRANT COUNTY VULNERABILITY TO DROUGHT**

Criterion	Value for Grant County	Meets Drought Vulnerability Criterion?
Percent of Time in Serious or Extreme Drought, 1895 – 1995	10 – 15	Yes
Irrigated Cropland (acres) Statewide Ranking for Irrigated Cropland Area	485,459 1	 Yes
Percent of Harvested Cropland That Is Irrigated Statewide Ranking for Irrigated Cropland Percentage	80.9% 5	 Yes
Market Value of Crops Statewide Ranking for Market Value of Crops	$626,501,000 1	 Yes
Population Growth, 2000 – 2006	7.9%	Yes
Median Household Income	$39,155	Yes
Unemployment Rate 20% Greater Than State Average	No	No

11.6.1 Population

The planning partnership has the ability to minimize any impacts on residents and water consumers in the county should several consecutive dry years occur. No significant life or health impacts are anticipated as a result of drought within the planning area.

11.6.2 Property

No structures will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

11.6.3 Critical Facilities

Critical facilities as defined for this plan will continue to be operational during a drought. Critical facility elements such as landscaping may not be maintained due to limited resources, but the risk to the planning area’s critical facilities inventory will be largely aesthetic. For example, when water conservation measures are in place, landscaped areas will not be watered and may die. These aesthetic impacts are not considered significant.

11.6.4 Environment

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

11.6.5 Economic Impact

Economic impact will be largely associated with industries that use water or depend on water for their business. For example, landscaping businesses were affected in the droughts of the past as the demand for service significantly declined because landscaping was not watered. Agricultural industries will be impacted if water usage is restricted for irrigation.

11.7. FUTURE TRENDS IN DEVELOPMENT

Each municipal planning partner in this effort has an established comprehensive plan that includes policies directing land use and dealing with issues of water supply and the protection of water resources. These plans provide the capability at the local municipal level to protect future development from the impacts of drought. All planning partners reviewed their general plans under the capability assessments performed for this effort. Deficiencies identified by these reviews can be identified as mitigation actions to increase the capability to deal with future trends in development.

11.8. SCENARIO

An extreme multiyear drought more intense than the 1977 drought could impact the region with little warning. Combinations of low precipitation and unusually high temperatures could occur over several consecutive years. Intensified by such conditions, extreme wildfires could break out throughout Grant County, increasing the need for water. Surrounding communities, also in drought conditions, could increase their demand for water supplies relied upon by the planning partnership, causing social and political conflicts. If such conditions persisted for several years, the economy of Grant County could experience setbacks, especially in water dependent industries.

11.9. ISSUES

The planning team has identified the following drought-related issues:

- Identification and development of alternative water supplies.
- Utilization of groundwater recharge techniques to stabilize the groundwater supply.
- The probability of increased drought frequencies and durations due to climate change.
- The promotion of active water conservation even during non-drought periods.

CHAPTER 12.
EARTHQUAKE

12.1. GENERAL BACKGROUND

12.1.1 How Earthquakes Happen

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Earthquakes tend to reoccur along faults, which are zones of weakness in the crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur.

Earthquakes in the Pacific Northwest have been studied extensively. It is generally agreed that three source zones exist for Pacific Northwest quakes: a shallow (crustal) zone; the Cascadia Subduction Zone; and a deep, intraplate "Benioff" zone. These are shown in Figure 12-1. More than 90 percent of Pacific Northwest earthquakes occur along the boundary between the Juan de Fuca plate and the North American plate.

DEFINITIONS

Earthquake—The shaking of the ground caused by an abrupt shift of rock along a fracture in the earth or a contact zone between tectonic plates.

Epicenter—The point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

Fault—A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other.

Focal Depth—The depth from the earth's surface to the hypocenter.

Hypocenter—The region underground where an earthquake's energy originates

Liquefaction—Loosely packed, water-logged sediments losing their strength in response to strong shaking, causing major damage during earthquakes.

Geologists classify faults by their relative hazards. Active faults, which represent the highest hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 11,000 years). Potentially active faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years). Determining if a fault is "active" or "potentially active" depends on geologic evidence, which may not be available for every fault. Although there are probably still some unrecognized active faults, nearly all the movement between the two plates, and therefore the majority of the seismic hazards, are on the well-known active faults.

Faults are more likely to have earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve accumulating tectonic stresses. A direct relationship exists between a fault's length and location and its ability to generate damaging ground motion at a given site. In some areas, smaller, local faults produce lower magnitude quakes, but ground shaking can be strong, and damage can be significant as a result of the fault's proximity to the area. In contrast, large regional faults can generate great magnitudes but, because of their distance and depth, may result in only moderate shaking in the area.

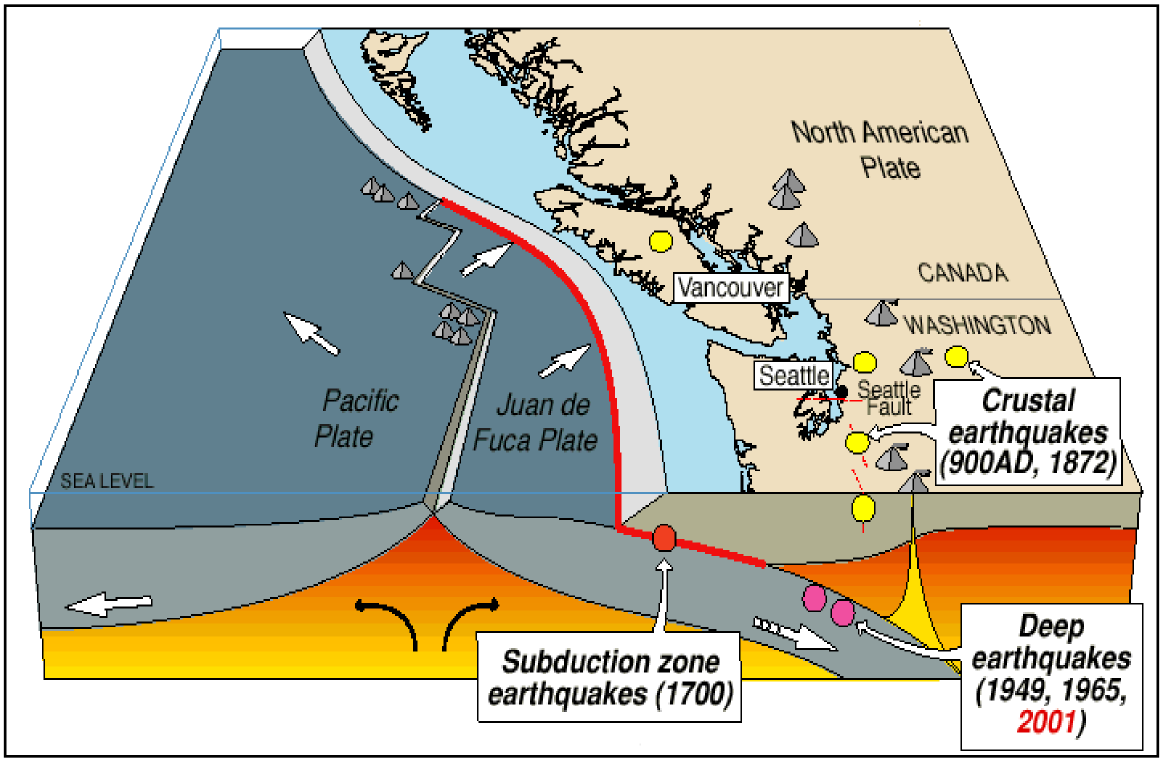


Figure 12-1. Earthquake Types in the Pacific Northwest

12.1.2 Earthquake Classifications

Earthquakes are classified according to the amount of energy released as measured by magnitude or intensity scales. Currently the most commonly used scales are the moment magnitude (Mw) scale, and the modified Mercalli intensity scale. Estimates of moment magnitude roughly match the local magnitude scale (ML) commonly called the Richter scale. One advantage of the moment magnitude scale is that, unlike other magnitude scales, it does not saturate at the upper end. That is, there is no value beyond which all large earthquakes have about the same magnitude. For this reason, moment magnitude is now the most often used estimate of large earthquake magnitudes. Table 12-1 presents a classification of earthquakes according to their magnitude. Table 12-2 compares the moment magnitude scale to the modified Mercalli intensity scale.

**TABLE 12-1.
EARTHQUAKE MAGNITUDE CLASSES**

Magnitude Class	Magnitude Range (M = magnitude)
Great	M > 8
Major	7 <= M < 7.9
Strong	6 <= M < 6.9
Moderate	5 <= M < 5.9
Light	4 <= M < 4.9
Minor	3 <= M < 3.9
Micro	M < 3

TABLE 12-2.
EARTHQUAKE MAGNITUDE AND INTENSITY

Magnitude (Mw)	Intensity (Modified Mercalli)	Description
1.0—3.0	I	I. Not felt except by a very few under especially favorable conditions
3.0—3.9	II—III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it is an earthquake. Standing cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0—4.9	IV—V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing cars rocked noticeably.
5.0—5.9	VI—VII	VI. Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken.
6.0—6.9	VII—IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	VIII and higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

12.1.3 Ground Motion

Earthquake hazard assessment is also based on expected ground motion. This involves determining the annual probability that certain ground motion accelerations will be exceeded, then summing the annual probabilities over the time period of interest. The most commonly mapped ground motion parameters are the horizontal and vertical peak ground accelerations (PGA) for a given soil or rock type. Instruments called accelerographs record levels of ground motion due to earthquakes at stations throughout a region. These readings are recorded by state and federal agencies that monitor and predict seismic activity.

Maps of PGA values form the basis of seismic zone maps that are included in building codes such as the International Building Code. Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. PGA values are directly related to these lateral forces that could damage "short period structures" (e.g. single-family dwellings). Longer period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table 12-3 lists damage potential by PGA factors compared to the Mercalli scale.

TABLE 12-3.
MERCALLI SCALE AND PEAK GROUND ACCELERATION COMPARISON

Mercalli Scale	Potential Damage	Estimated PGA
I	None	0.017
II-III	None	0.017
IV	None	0.014-0.039
V	Very Light	0.039-0.092
VI	None to Slight; USGS-Light	0.02-0.05
	Unreinforced Masonry-Stair Step Cracks; Damage to Chimneys; Threshold of Damage	0.04-0.08 0.06-0.07 0.06-0.13 0.092-0.18
VII	Slight-Moderate; USGS-Moderate	0.05-0.10
	Unreinforced Masonry-Significant; Cracking of parapets	0.08-0.16 0.10-0.15
	Masonry may fail; Threshold of Structural Damage	0.1 0.18-0.34
VIII	Moderate-Extensive; USGS: Moderate-Heavy	0.10-0.20
	Unreinforced Masonry-Extensive Cracking; fall of parapets and gable ends	0.16-0.32 0.25-0.30 0.13-0.25 0.2 0.35-0.65
IX	Extensive-Complete; USGS-Heavy	0.20-0.50
	Structural collapse of some un-reinforced masonry buildings; walls out of plane. Damage to seismically designed structures	0.32-0.55 0.50-0.55 0.26-0.44 0.3 0.65-1.24
X	Complete ground failures; USGS- Very Heavy (X+); Structural collapse of most un-reinforced masonry buildings; notable damage to seismically designed structures; ground failure	0.50-1.00

12.1.4 Effect of Soil Types

The impact of an earthquake on structures and infrastructure is largely a function of ground shaking, distance from the source of the quake, and liquefaction, a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. Liquefaction generally occurs in soft, unconsolidated sedimentary soils. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 12-4 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are commonly most affected by ground shaking have NEHRP Soils D, E and F. In general, these areas are also most susceptible to liquefaction.

TABLE 12-4.
NEHRP SOIL CLASSIFICATION SYSTEM

NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	

12.2. HAZARD PROFILE

Earthquakes can last from a few seconds to over five minutes; they may also occur as a series of tremors over several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties generally result from falling objects and debris, because the shocks shake, damage or demolish buildings and other structures. Disruption of communications, electrical power supplies and gas, sewer and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides or releases of hazardous material, compounding their disastrous effects.

Small, local faults produce lower magnitude quakes, but ground shaking can be strong and damage can be significant in areas close to the fault. In contrast, large regional faults can generate earthquakes of great magnitudes but, because of their distance and depth, they may result in only moderate shaking in an area.

12.2.1 Past Events

Table 12-5 lists past seismic events that have either occurred in the planning area, or have in some manner impacted the region. Many of the earthquakes which occur in Eastern Washington occur in clusters, mostly near the Saddle Mountains in folded volcanic rocks, which were extruded in southeastern Washington from 16.5 to 6 million years ago.

TABLE 12-5.
HISTORICAL EARTHQUAKES IMPACTING THE PLANNING AREA

Year	Magnitude	Fault	Region Impacted

3/25/2010	3.2	Moses Lake	Shallow
2/28/2001	6.8	Olympia (Nisqually)	Beinoff
6/10/2001	5.0	Matlock	Benioff
7/3/1999	5.8	8.0 km N of Satsop	Benioff
1/31/1999	3.1	Grand Coulee Dam	Shallow Crustal
6/24/1997	4.6	Wilson Creek/Grand Coulee Dam Area	Shallow Crustal
5/3/1996	5.5	Duvall	Shallow Crustal
5/10/1989	4.4	Grand Coulee Dam	Shallow Crustal
2/14/1981	5.5	Mt. St. Helens	Crustal
12/20/1973	4.4	Othello	Shallow Crustal
4/29/1965	6.6	18.3 KM N of Tacoma (Sea Tac)	Benioff
8/5/1959	5.5	Eastside of North Cascades	Shallow Crustal
1/13/1949	7.0	12.3 KM ENE of Olympia	Benioff
1872	7.4	North Cascades	Shallow Crustal (largest historic EQ in WA history)

12.2.2 Location

Identifying the extent and location of an earthquake is not as simple as it is for other hazards such as flood, landslide or wild fire. The impact of an earthquake is largely a function of the following components:

- Ground shaking (ground motion accelerations)
- Liquefaction (soil instability)
- Distance from the source (both horizontally and vertically).

Mapping that shows the impacts of these components was used to assess the risk of earthquakes within the planning area. While the impacts from each of these components can build upon each other during an earthquake event, the mapping looks at each component individually. The mapping used in this assessment is described below.

Shake Maps

A shake map is a representation of ground shaking produced by an earthquake. The information it presents is different from the earthquake magnitude and epicenter that are released after an earthquake because shake maps focus on the ground shaking resulting from the earthquake, rather than the parameters describing the earthquake source. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth’s crust. A shake map shows the extent and variation of ground shaking in a region immediately following significant earthquakes.

Ground motion and intensity maps are derived from peak ground motion amplitudes recorded on seismic sensors (accelerometers), with interpolation based on estimated amplitudes where data are lacking, and site amplification corrections. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. Two types of shake map are typically generated from the data:

- A probabilistic seismic hazard map shows the hazard from earthquakes that geologists and seismologists agree could occur. The maps are expressed in terms of probability of exceeding a certain ground motion, such as the 10-percent probability of exceedance in 50 years. Figure 12-2 demonstrates this probability across Washington State. This level of ground shaking has been used for designing buildings in high seismic areas. Maps 12-4 and 12-5 show the estimated ground motion for the 100-year and 500-year probabilistic earthquakes in Grant County.
- Earthquake scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. Maps of these scenarios can be used to support all phases of emergency management. One scenario was selected for this plan:
  - 1) Map 12-3 shows the estimated ground motion for a 7.3M event on the Saddle Mountain Fault.

NEHRP Soil Maps

NEHRP soil types define the locations that will be significantly impacted by an earthquake. NEHRP Soils B and C typically can sustain low-magnitude ground shaking without much effect. The areas that are most commonly affected by ground shaking have NEHRP Soils D, E and F. Map 12-1 shows NEHRP soil classifications in the county.

Liquefaction Maps

Soil liquefaction maps are useful tools to assess potential damage from earthquakes. When the ground liquefies, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. In general, areas with NEHRP Soils D, E and F are also susceptible to liquefaction. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it, creating sand boils. Map 12-2 shows the liquefaction susceptibility in Grant County.

12.2.3 Frequency

More than 1,000 earthquakes are recorded in the state annually. A dozen or more earthquakes cause shaking and occasional damage. Most earthquakes occur in Western Washington; however, Washington State’s largest earthquakes of 1872 occurred east of the Cascade Crest.

Those earthquakes occurring in Grant County historically have not caused damage, and are considered more than negligible. The areas near the Frenchman Hills and Saddle Mountain, as well as the areas near Beesley Hill and upper Banks Lake regions have recorded quakes since 1840.

12.2.4 Severity

The severity of an earthquake can be expressed in terms of intensity or magnitude. Intensity represents the observed effects of ground shaking on people, buildings, and natural features. The USGS has created ground motion maps based on current information about several fault zones. These maps show the PGA that has a certain probability (2 percent or 10 percent) of being exceeded in a 50-year period. The PGA is measured in numbers of g’s (the acceleration associated with gravity). Figure 12-2 shows the PGAs with a 2-percent exceedance chance in 50 years in Washington.

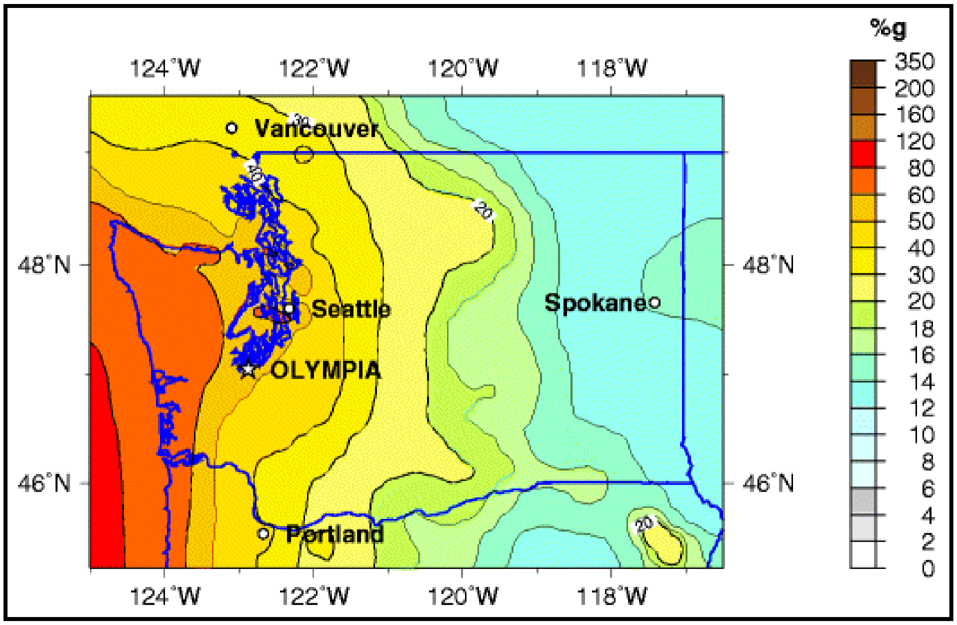


Figure 12-2. PGA with 2-Percent Probability of Exceedance in 50 Years, Northwest Region

Magnitude is related to the amount of seismic energy released at the hypocenter of an earthquake. It is determined by the amplitude of the earthquake waves recorded on instruments. Whereas intensity varies depending on location with respect to the earthquake epicenter, magnitude is represented by a single, instrumentally determined value for each earthquake event.

In simplistic terms, the severity of an earthquake event can be measured in the following terms:

- How hard did the ground shake?
- How did the ground move? (Horizontally or vertically)
- How stable was the soil?
- What is the fragility of the built environment in the area of impact?

Grant County as a whole could be severely impacted by an earthquake which effects any of its 64 dams currently listed with the Department of Ecology, including the Grand Coulee Dam. Grand Coulee Dam is a gravity fed dam on the Columbia River which maintains three hydroelectric power plants, also providing irrigation to agricultural lands within the planning area. The dam is one of the largest concrete structures in the world. Power generation could be greatly impacted by an earthquake occurring within the planning area as the potential exists for the collapse of transmission lines, or even a potential breach of the dam itself. This would have far reaching implications, and could potentially impact a geographic area much greater than the focus of this plan. This would have disastrous effects on local and regional economies, and could also mean that recovery, repair and rebuilding time for the planning area would be very lengthy. In addition, large intensity quakes could also cause bridge failures, interrupt transportation routes and create accidents on rail systems.

12.2.5 Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system.

12.3. SECONDARY HAZARDS

Earthquakes can cause large and sometimes disastrous landslides and mudslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes.

12.4. CLIMATE CHANGE IMPACTS

The impacts of global climate change on earthquake probability are unknown. Some scientists say that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth’s crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska may be opening the way for future earthquakes (NASA, 2004).

Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

12.5. EXPOSURE

12.5.1 Population

The entire population of Grant County is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure is dependent on many factors, including the age and construction type of the structures people live in, the soil type their homes are constructed on, their proximity to fault location, etc. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

12.5.2 Property

The Grant County Assessor estimates that there are 36,576 buildings in Grant County, with a total assessed value of $7.6 billion. Since all structures in the planning area could be susceptible to earthquake impacts to varying degrees, this total represents the county-wide property exposure to seismic events. Most of the buildings (73 percent) are residential.

Building Age

The Washington State Building Code Council identifies significant milestones in building and seismic code requirements that directly affect the structural integrity of development in Washington. Using these time periods, the planning team used HAZUS to identify the number of structures within the County by date of construction. Table 12-6 shows the results of this analysis.

**TABLE 12-6.
AGE OF STRUCTURES IN GRANT COUNTY**

Time Period	Number of Current County Structures Built in Period	Significance of Time Frame
Pre-1933	847	Before 1933, there were no explicit earthquake requirements in building codes. State law did not require local governments to have building officials or issue building permits.
1933-1940	953	In 1940, the first strong motion recording was made.
1941-1960	8,351	In 1960, the Structural Engineers Association of California published guidelines on recommended earthquake provisions.
1961-1975	4,797	In 1975, significant improvements were made to lateral force requirements.
1976-1994	9,509	In 1994, the Uniform Building Code was amended to include provisions for seismic safety.
1994 - present	12,119	Seismic code is currently enforced.
Total	**36,576**	

The number of structures does not reflect the number of total housing units, as many multi-family units and attached housing units are reported as one structure. Approximately 33 percent of the planning area's structures were constructed after the Uniform Building Code was amended in 1994 to include seismic safety provisions. Approximately 2 percent were built before 1933 when there were no building permits, inspections, or seismic standards.

Soft-Story Buildings

A soft-story building is a multi-story building with one or more floors that are "soft" due to structural design. If a building has a floor that is 70-percent less stiff than the floor above it, it is considered a soft-story building. This soft story creates a major weak point in an earthquake. Since soft stories are typically associated with retail spaces and parking garages, they are often on the lower stories of a building. When they collapse, they can take the whole building down with them, causing serious structural damage that may render the structure totally unusable.

These floors can be especially dangerous in earthquakes, because they cannot cope with the lateral forces caused by the swaying of the building during a quake. As a result, the soft story may fail, causing what is known as a soft story collapse. Soft-story collapse is one of the leading causes of earthquake damage to private residences.

Exposure associated with soft story construction in the planning area is not currently known. This type of data will need to be generated to support future risk assessments of the earthquake hazard.

12.5.3 Critical Facilities and Infrastructure

All critical facilities in Grant County are exposed to the earthquake hazard. Table 12-11 lists the number of each type of facility by jurisdiction. Hazardous materials releases can occur during an earthquake from fixed facilities or transportation-related incidents. Transportation corridors can be disrupted during an earthquake, leading to the release of materials to the surrounding environment. Facilities holding hazardous materials are of particular concern because of possible isolation of neighborhoods surrounding them. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment.

12.5.4 Environment

Secondary hazards associated with earthquakes will likely have some of the most damaging effects on the environment. Earthquake-induced landslides can significantly impact surrounding habitat. It is also possible for streams to be rerouted after an earthquake. This can change the water quality, possibly damaging habitat and feeding areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology.

12.6. VULNERABILITY

Earthquake vulnerability data was generated using a Level 2 HAZUS-MH analysis. Once the location and size of a hypothetical earthquake are identified, HAZUS-MH estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up.

12.6.1 Population

Three population groups are particularly vulnerable to earthquake hazards:

- **Linguistically Isolated Populations**——Approximately 8,400 residents in the planning area census blocks on NEHRP D and E soils do not speak English as their native language. This is about 35 percent of all residents in these census blocks. Problems arise when there is an urgent need to inform non-English speaking residents of an earthquake event. They are vulnerable because of difficulties in understanding hazard-related information from predominantly English-speaking media and government agencies.
- **Population Below Poverty Level**—Approximately 750 households in the planning area census blocks on NEHRP D and E soils are listed as being below the poverty level. This is about 10 percent of all households in these census blocks. These households may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Poorer residents are also less likely to have insurance to compensate for losses in earthquakes.
- **Population Over 65 Years Old**—Approximately 1,200 residents in the planning area census blocks on NEHRP D and E soils are over 65 years old. This is about 5.5 percent of all residents in these census blocks. This population group is vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also

have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations.

Impacts on persons and households in the planning area were estimated for the 100-year and 500-year earthquakes and the one scenario event through the Level 2 HAZUS-MH analysis. Table 12-7 summarizes the results.

TABLE 12-7.
ESTIMATED EARTHQUAKE IMPACT ON PERSON AND HOUSEHOLDS

	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
100-Year Earthquake	2	1
500-Year Earthquake	32	25
Saddle Mountain Earthquake	76	90

12.6.2 Property

Property losses were estimated through the Level 2 HAZUS-MH analysis for the 100-year and 500-year earthquakes and the one scenario event. Tables 12-8 and 12-9 show the results for two types of property loss:

- Structural loss, representing damage to building structures
- Non-structural loss, representing the value of lost contents and inventory, relocation, income loss, rental loss, and wage loss.

The total of the two types of losses is also shown in the tables. A summary of the property-related loss results is as follows:

- For a 100-year probabilistic earthquake, the estimated damage potential is $5.7 million, or 0.1 percent of the total assessed value for the planning area.
- For a 500-year earthquake, the estimated damage potential is $60.2 million, or 0.8 percent of the total assessed value for the planning area.
- For a 7.3-magnitude event on the Saddle Mountain Fault, the estimated damage potential is $189 million, or 2.5 percent of the total assessed value for the planning area.

The HAZUS-MH analysis also estimated the amount of earthquake-caused debris in the planning area for the 100-year and 500-year earthquakes and the one scenario event, as summarized in Table 12-.

12.6.3 Critical Facilities and Infrastructure

Level of Damage

HAZUS-MH classifies the vulnerability of critical facilities to earthquake damage in five categories: no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a vulnerability category to each critical facility in the planning area except hazmat facilities and “other infrastructure” facilities, for which there are no established damage functions. The analysis was performed for the 100-year event and the

Saddle Mountain Fault scenario, which have, respectively, the highest probability of occurrence and the largest potential impact on the planning area.

Table 12-8.
Earthquake Building Loss Potential—Probabilistic

	Estimated Earthquake Loss Value					
	100- Year Probabilistic Earthquake			500- Year Probabilistic Earthquake		
Jurisdiction	Structural	Non-Structural	**Total**	Structural	Non-Structural	**Total**
Ephrata Area	$1,465,371	$435,768	**$1,901,139**	$12,933,800	$4,280,421	**$17,214,221**
Moses Lake Area	$642,273	$101,432	**$743,704**	$8,373,404	$2,571,677	**$10,945,081**
Quincy Area	$420,829	$87,022	**$507,851**	$3,788,763	$1,004,566	**$4,793,329**
North of I-90	$1,394,354	$253,796	**$1,648,150**	$13,379,918	$3,633,244	**$17,013,162**
South of I-90	$819,033	$124,713	**$943,746**	$8,243,946	$2,043,741	**$10,287,687**
Total	**$4,741,859**	**$1,002,731**	**$5,744,590**	**$46,719,831**	**$13,533,649**	**$60,253,480**

Table 12-9.
Earthquake Building Loss Potential—Scenario Event

	Estimated Earthquake Loss Value		
	7.3 M Saddle Mountain Fault		
Jurisdiction	Structural	Non-Structural	**Total**
Ephrata Area	$766,564	$408,659	**$1,175,224**
Moses Lake Area	$6,519,269	$3,618,228	**$10,137,497**
Quincy Area	$1,930,473	$633,977	**$2,564,451**
North of I-90	$5,594,157	$2,549,273	**$8,143,430**
South of I-90	$130,192,998	$37,408,090	**$167,601,088**
Total	**$145,003,461**	**$44,618,229**	**$189,621,690**

TABLE 12-10.
ESTIMATED EARTHQUAKE-CAUSED DEBRIS

	Debris to Be Removed (tons)
100-Year Earthquake	4000
500-Year Earthquake	36,720
Saddle Mountain Scenario	205,690

Table 12-11.
Critical Facility Vulnerability to 100-Year Earthquake Event

Category[a]	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	15	0	0	0	0
Government Functions	70	0	0	0	0
Protective Functions	45	0	0	0	0
Schools	79	0	0	0	0
Bridges	272	0	0	0	0
Water supply	13	0	0	0	0
Wastewater	7	0	0	0	0
Power	14	0	0	0	0
Communications	22	0	0	0	0
Total	**537**	**0**	**0**	**0**	**0**

a. Vulnerability not estimated for hazmat facilities or for "other" facilities due to lack of established damage functions for these type facilities.

Table 12-12.
Critical Facility Vulnerability to Saddle Mountain Fault Scenario

Category [a]	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	11	2	2	0	0
Government Functions	52	2	12	4	0
Protective Functions	42	2	1	0	0
Schools	72	7	0	0	0
Bridges	260	12	0	0	0
Water supply	11	2	0	0	0
Wastewater	7	0	0	0	0
Power	11	3	0	0	0
Communications	20	2	0	0	0
Total	**486**	**32**	**15**	**4**	**0**

a. Vulnerability not estimated for hazmat facilities or for "other" facilities due to lack of established damage functions for these type facilities.

Time to Return to Functionality

HAZUS-MH estimates the time to restore critical facilities to fully functional use. Results are presented as probability of being functional at specified time increments: 1, 3, 7, 14, 30 and 90 days after the event. For example, HAZUS-MH may estimate that a facility has 5 percent chance of being fully functional at Day 3, and a 95-percent chance of being fully functional at Day 90. The analysis of critical facilities in the planning area was performed for the 100-year and Saddle Mountain Fault earthquake events. Tables 12-13 and 12 -14 summarize the results.

Table 12-13.
Functionality of Critical Facilities for 100-Year Event

	# of Critical	Probability of Being Fully Functional (%)					
Planning Unit	Facilities	at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	15	99	99	100	100	100	100
Government Functions	70	98	98	99	99	100	100
Protective Functions	45	98	99	99	100	100	100
Schools	79	98	99	99	100	100	100
Bridges	272	99	100	100	100	100	100
Water supply	13	99	100	100	100	100	100
Wastewater	7	99	100	100	100	100	100
Power	14	98	99	99	100	100	100
Communications	22	99	99	100	100	100	100
Total/Average	**537**	**98.6**	**99.2**	**99.6**	**99.9**	**100.0**	**100.0**

Table 12-14.
Functionality of Critical Facilities for Saddle Mountain Fault Scenario

Planning Unit	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	15	82	82	90	91	99	99
Government Functions	70	78	78	90	90	96	99
Protective Functions	45	90	90	97	98	98	99
Schools	79	89	89	97	97	99	100
Bridges	272	95	96	97	97	97	98
Water supply	13	83	97	98	99	99	100
Wastewater	7	82	96	99	99	100	100
Power	14	74	92	99	99	99	100
Communications	22	96	99	99	99	100	100
Total/Average	**537**	**85.4**	**91.0**	**96.2**	**96.6**	**98.6**	**99.4**

12.6.4 Environment

The environment vulnerable to earthquake hazard is the same as the environment exposed to the hazard.

12.7. FUTURE TRENDS IN DEVELOPMENT

Land use in the planning area will be directed by general plans adopted under Washington's Growth Management Act (GMA) which addresses geological hazard areas as one of the elements within the Critical Areas Ordinance of GMA, and the Washington State Building Council's adoption of the 2009 International Building Codes. The safety elements of the general plans establish standards and plans for the protection of the community from hazards. The information in this plan provides the participating partners a tool to ensure that there is no increase in exposure in areas of high seismic risk. Development in the planning area will be regulated through building standards and performance measures so that the degree of risk will be reduced. The geologic hazard portions of the planning area are heavily regulated under Washington's planning regulations. The International Building Code also establishes provisions to address seismic risk.

12.8. SCENARIO

An earthquake does not have to occur within Grant County to have a significant impact on the people, property and economy of the county.

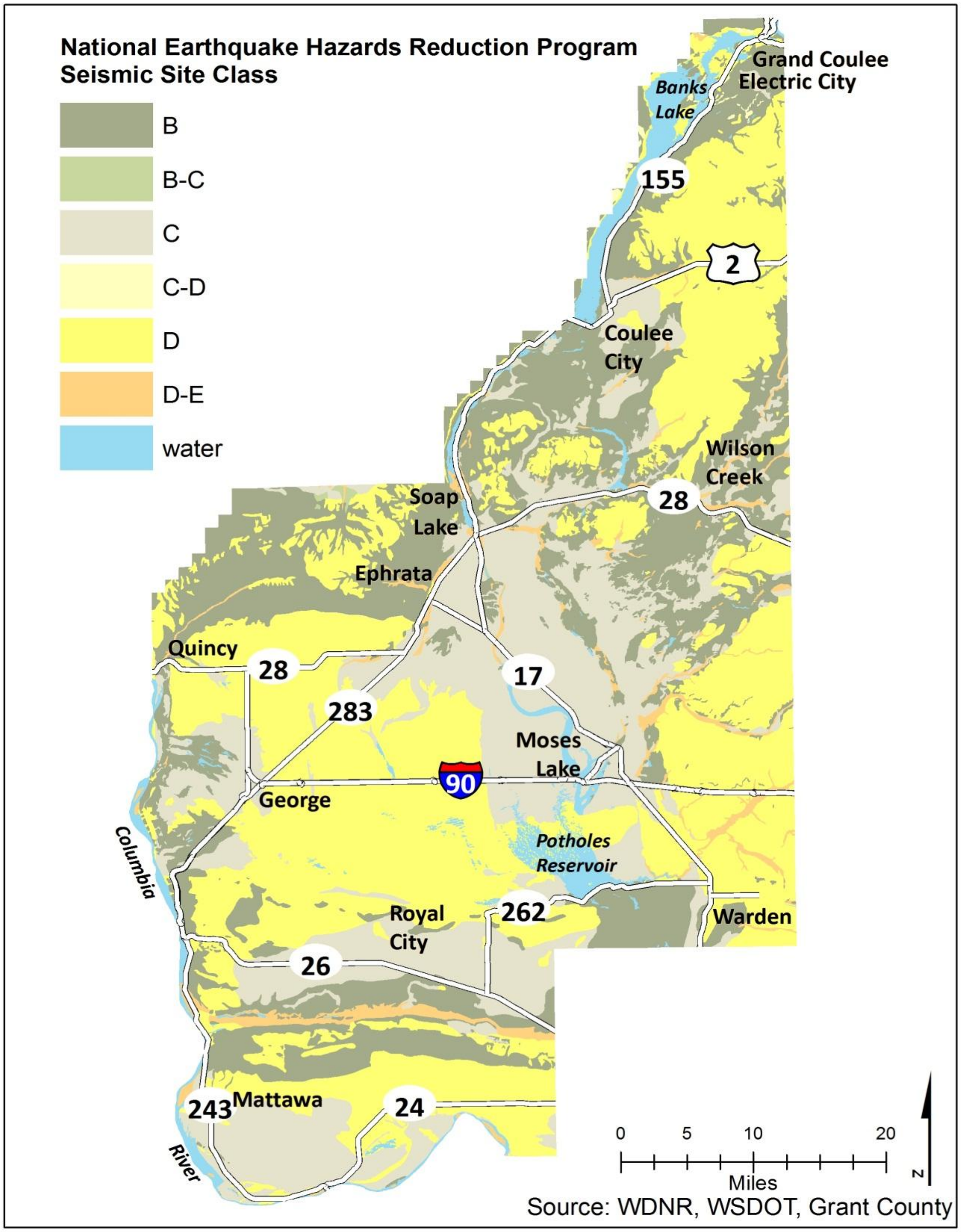
Any seismic activity of 6.0 or greater on faults within the planning area would have significant impacts throughout the county. Potential warning systems could give approximately 40 seconds notice that a major earthquake is about to occur. This would not provide adequate time for preparation. Earthquakes of this magnitude or higher would lead to massive structural failure of property on NEHRP C, D, E, and F soils. Levees and revetments built on these poor soils would likely fail, representing a loss of critical infrastructure. These events could cause secondary hazards, including landslides and mudslides that would further damage structures. River valley hydraulic-fill sediment areas are also vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction would occur in water-saturated sands, silts or gravelly soils.

This modeling of a 7.4 earthquake scenario on the Saddle Mountain Fault, located within Grant County, indicates that the number of people injured in the scenario would likely be highest in Grant County. There would still likely be injuries in nearby counties like Kittitas, Yakima, Franklin, and Benton Counties (FEMA, USGS, WA-EMD, WA-DNR, 2012-13). For more information and to access the scenario event online, go to:
https://fortress.wa.gov/dnr/seismicscenarios/index.html

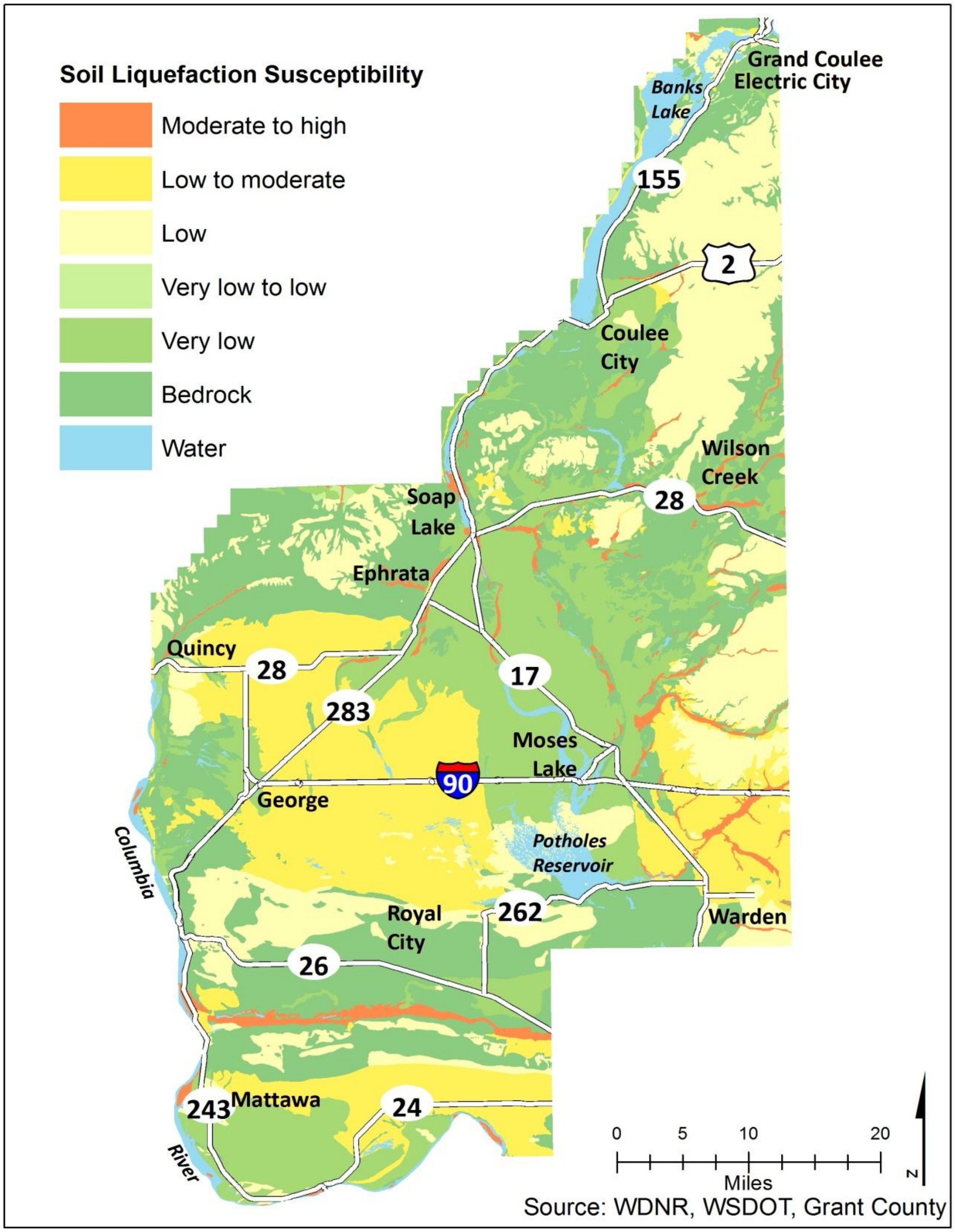
12.9. ISSUES

Important issues associated with an earthquake include but are not limited to the following:

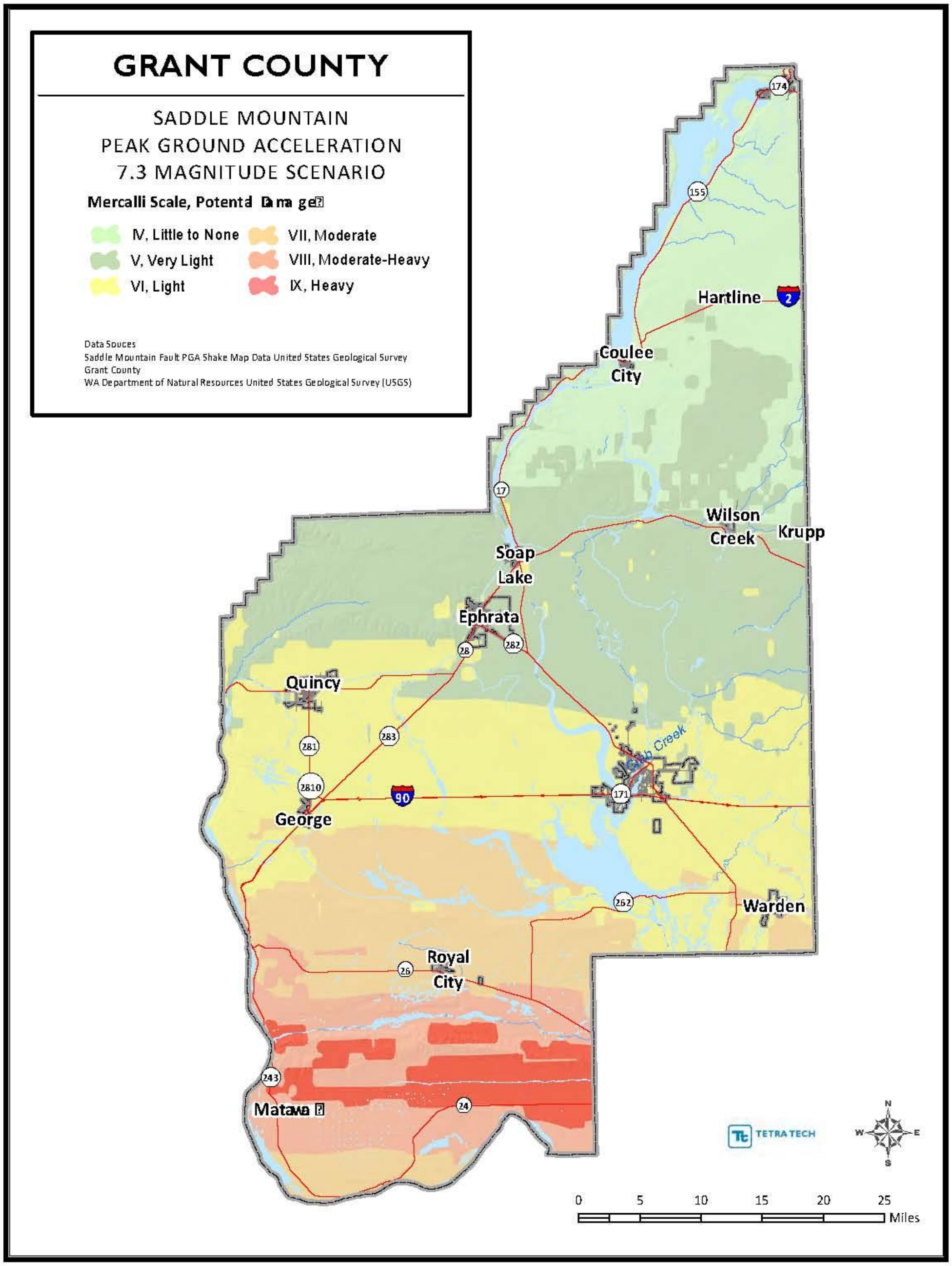
- More information is needed on the exposure and performance of soft-story construction within the planning area.
- More than 40 percent of the planning area's building stock was built prior to 1975, when seismic provisions became uniformly applied through building code applications.
- Critical facility owners should be encouraged to create or enhance Continuity of Operations Plans using the information on risk and vulnerability contained in this plan.
- Geotechnical standards should be established that take into account the probable impacts from earthquakes in the design and construction of new or enhanced facilities.
- There are a large number of dams within the planning area. Dam failure warning and evacuation plans and procedures should be reviewed and updated to reflect the dams' risk potential associated with earthquake activity in the region.
- Earthquakes could trigger other natural hazard events such as dam failures and landslides, which could severely impact the county.
- A worst-case scenario would be the occurrence of a large seismic event during a flood or high-water event. Dam failures could happen at multiple locations, increasing the impacts of the individual events.



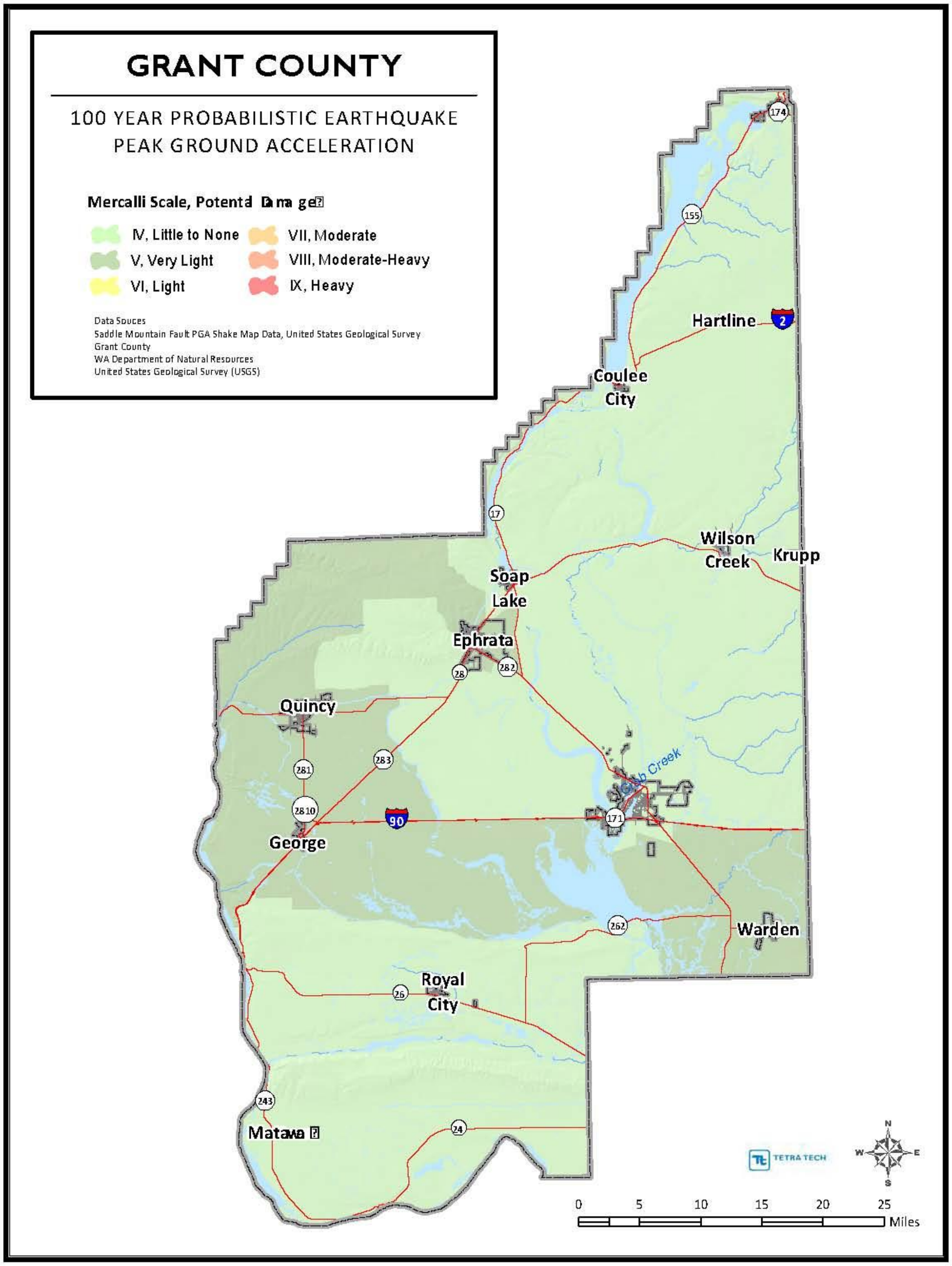
Map 12-1: National Earthquake Hazards Reduction Program (NEHRP) Site Class Map of Grant County, Washington



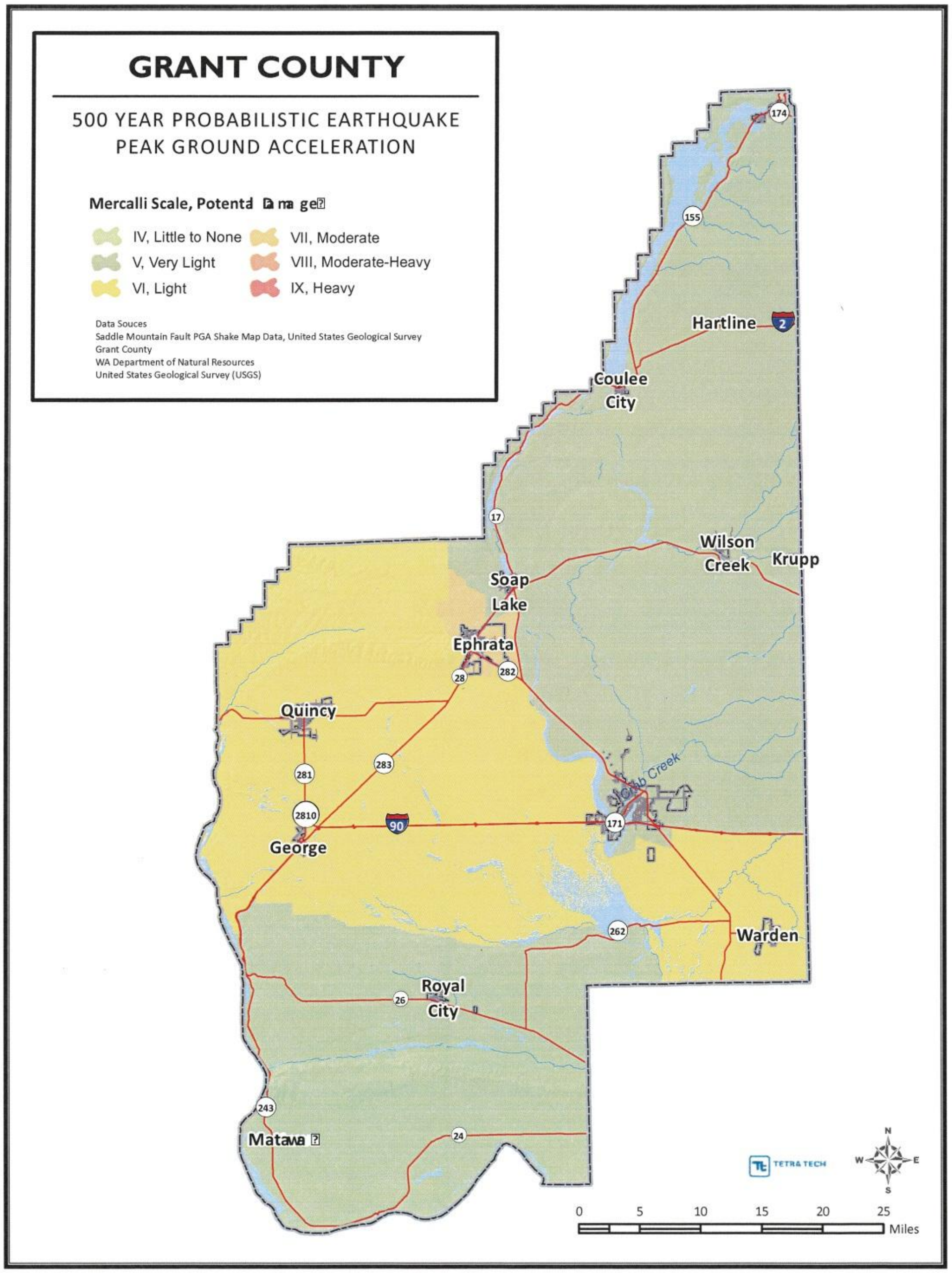
Map 12-2: Liquefaction Susceptibility Map of Grant County Washington



Map 12-3: Saddle Mountain Fault, 7.35 Magnitude Earthquake Scenario Map



Map 12-4 100 Year Probabilistic Earthquake



Map 12-5 500 Year Probabilistic Earthquake

CHAPTER 13.
FLOOD

13.1. GENERAL BACKGROUND

A floodplain is the area adjacent to a river, creek or lake that becomes inundated during a flood. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.

When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater. These are often important aquifers, the water drawn from them being filtered compared to the water in the stream. Fertile, flat reclaimed floodplain lands are commonly used for agriculture, commerce and residential development.

Connections between a river and its floodplain are most apparent during and after major flood events. These areas form a complex physical and biological system that not only supports a variety of natural resources but also provides natural flood and erosion control. When a river is separated from its floodplain with levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced.

DEFINITIONS

Flood—The inundation of normally dry land resulting from the rising and overflowing of a body of water.

Floodplain—The land area along the sides of a river that becomes inundated with water during a flood.

100-Year Floodplain—The area flooded by a flood that has a 1-percent chance of being equaled or exceeded each year. This is a statistical average only; a 100-year flood can occur more than once in a short period of time. The 1-percent annual chance flood is the standard used by most federal and state agencies.

Return Period—The average number of years between occurrences of a hazard (equal to the inverse of the annual likelihood of occurrence).

Riparian Zone—The area along the banks of a natural watercourse.

13.1.1 Measuring Floods and Floodplains

The frequency and severity of flooding are measured using a discharge probability, which is a statistical tool used to define the probability that a certain river discharge (flow) level will be equaled or exceeded within a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1-percent chance of being equaled or exceeded in any given year. The “annual flood” is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

The extent of flooding associated with a 1-percent annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the elevation of water that will result from a given discharge level, which is one of the most important factors used in estimating flood damage.

13.1.2 Floodplain Ecosystems

Floodplains can support ecosystems that are rich in quantity and diversity of plant and animal species. A floodplain can contain 100 or even 1000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly; however the surge of new growth endures for some time. This makes floodplains particularly valuable for agriculture. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and very quick-growing compared to non-riparian trees.

13.1.3 Effects of Human Activities

Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; land is fertile and suitable for farming; transportation by water is easily accessible; and land is flatter and easier to develop. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream's capacity to contain flows, and it increases flow rates or velocities downstream during all stages of a flood event. Human activities can interface effectively with a floodplain as long as steps are taken to mitigate the activities' adverse impacts on floodplain functions.

13.1.4 Federal Flood Programs

National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study (FIS). The study presents water surface elevations for floods of various magnitudes, including the 1-percent annual chance flood and the 0.2-percent annual chance flood (the 500-year flood). Base flood elevations and the boundaries of the 100- and 500-year floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principle tool for identifying the extent and location of the flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under their floodplain management program.

Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.

- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmon species.

Grant County entered the NFIP on September 30, 1988. Structures permitted or built in the County before then are called “pre-FIRM” structures, and structures built afterwards are called “post-FIRM.” The insurance rate is different for the two types of structures. The effective date for the current countywide FIRM is February 8, 2009. This map is a DFIRM (digital flood insurance rate map).

All incorporated cities in Grant County also participate in the NFIP with the exception of the City of Grand Coulee, which was sanction by the program on February 18, 2010. All of the county and its remaining cities are currently in good standing with the provisions of the NFIP. Currently, the unincorporated portion of the County has 41 flood insurance policies in place.

The City of Moses Lake entered the NFIP program on January 5, 1989, and currently has 19 NFIP policies in place. The City of Ephrata has 288 policies in place, joining the NFIP program on September 30, 1988. The current effective date of Ephrata’s maps are February 28, 2009. The Town of Warden entered the program on February 18, 2009, which is also the date of its most current maps. Warden has no NFIP policies in place within its boundary.

Compliance is monitored by FEMA regional staff and by the Washington State Department of Ecology. Maintaining compliance under the NFIP is an important component of flood risk reduction. All planning partners that participate in the NFIP have identified initiatives to maintain their compliance and good standing.

The Community Rating System

The CRS is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

- Reduce flood losses.
- Facilitate accurate insurance rating.
- Promote awareness of flood insurance.

For participating communities, flood insurance premium rates are discounted in increments of 5 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. (Class 10 communities are those that do not participate in the CRS; they receive no discount.) The CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness

Figure 13-1 shows the nationwide number of CRS communities by class as of May 1, 2010, when there were 1,138 communities receiving flood insurance premium discounts under the CRS program. Twenty-seven communities in Washington State take part in the CRS program, including participation by the first Native American Tribe in the Nation – the Lower Elwha Tribe. Washington is also home to two of the highest rated counties across the country (King and Pierce).

CRS activities can help to save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

Currently, only the City of Ephrata is participating in the CRS program. The planning partnership's overall CRS status is summarized in Table 13-1. Many of the mitigation actions identified in Volume 2 of this plan are creditable activities under the CRS program. Therefore, successful implementation of this plan offers the potential for all communities within the County to enhance their CRS classifications and for currently non-participating communities to join the program.

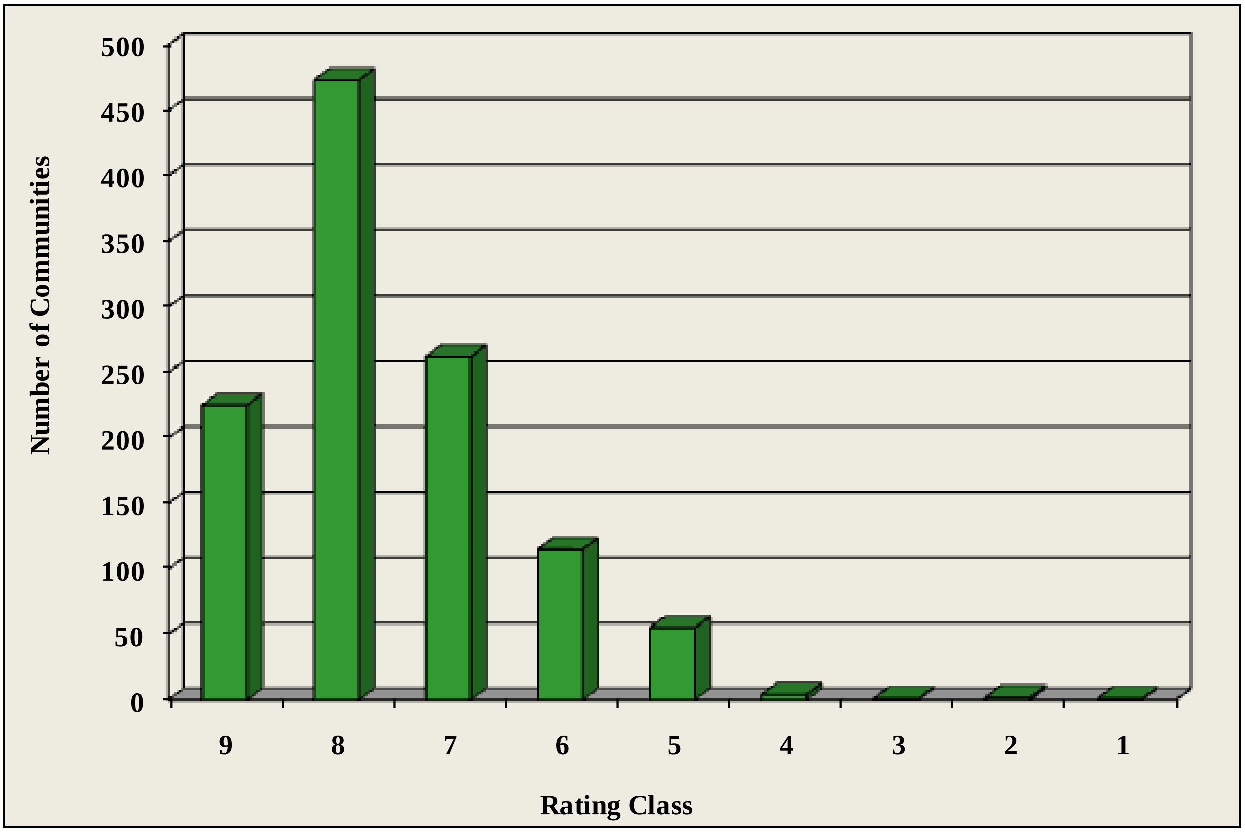


Figure 13-1. CRS Communities by Class Nationwide as of May 1, 2010

TABLE 13-1.
CRS COMMUNITY STATUS IN GRANT COUNTY

Community	NFIP Community #	CRS Entry Date	Current CRS Classification	% Premium Discount, SFHA/non-SFHA	Total Premium Savings
Grant County	530049	Not Participating	--	--	$0
Ephrata	530051	10/1/2000	7	15/10	$187.00
Moses Lake	530053	Not Participating	--	--	$0
Warden	530304	Not Participating	--	--	$0

13.2. HAZARD PROFILE

Flooding in Grant County is primarily a result of two factors: heavy snowfall, followed by rapidly rising temperatures, or high-intensity, short-duration (1 to 3 hours) storms concentrated on a stream reach with already saturated soil. Two types of flooding are typical:

- Flash floods that occur suddenly after a brief but intense downpour. They move rapidly, end suddenly, and can occur in areas not generally associated with flooding (such as subdivisions not adjacent to a water body and areas serviced by underground drainage systems). Although the duration of these events is usually brief, the damage they cause can be severe. Flash floods cannot be predicted accurately and happen whenever there are heavy storms.
- Riverine floods described in terms of their extent (including the horizontal area affected and the vertical depth of floodwater) and the related probability of occurrence (expressed as the percentage chance that a flood of a specific extent will occur in any given year).

In addition, because of the geological makeup of Grant County, there are many glacially formed coulees comprised of a gully or ravine which is usually dry, but becomes sizeable during rainy weather. There are also areas scattered throughout the County which are susceptible to dry washes as a result of heavy rains as well.

Flooding is predominantly confined within traditional riverine valleys when excessive water discharge causes the river or stream channels to overflow. Within Grant County, both the Columbia River and Crab Creek, and their tributaries, are susceptible to flooding. Locally, some natural or manmade levees separate channels from floodplains and cause independent overland flow paths. Occasionally, railroad, highway or canal embankments form barriers, resulting in ponding or diversion of the flow. Some localized flooding not associated with stream overflow can occur where there are no drainage facilities to control flows or when runoff volumes exceed the design capacity of drainage facilities.

The threat of flooding in Grant County is greatest in the months of December through February,although flood events may occur during other months of the year. While customarily high peak flows result from when significant snowfall is present, followed by rapidly rising temperature and/or heavy rain, increased flow rates from the hydroelectric dams further increase the potential of flooding due to their effect on river discharge flows.

Principal Flooding Sources

Grant County lies within the Columbia Basin area, and the county seat, Ephrata, is headquarters to the world's largest irrigation project, the Columbia Basin Project. The Columbia River is the second largest river system in the United States behind the Mississippi River. From its source in Canada, the Columbia River flows 1,243 miles and empties into the Pacific Ocean at Astoria, Oregon. The river drains an area of approximately 250,000 square miles. Tributaries to the Columbia River that sources of flooding within the planning area are described as follows:

Crab Creek

Crab Creek is the primary flooding source in Moses Lake, Wilson Creek, and unincorporated Grant County. Crab Creek flows generally from the eastern corporate limits to the western corporate limits and is joined by Wilson Creek near the southeast corner of the town. According to the USGS, Crab Creek serves a drainage area of some 2,228 square miles. Most flooding problems in the Crab Creek Basin occur from extreme runoff events of short duration. These flash floods are usually caused by heavy rain on snow covered frozen ground. This type of event will be referred to as a winter rain flood in this study. Severe spring and summer thunderstorms can also cause extensive flooding.

The February 1957 flood is the largest flood recorded at the City of Moses Lake and the Town of Wilson Creek with peak flows in excess of 12,500 CFS. This event had an estimated recurrence interval of 65 years. Near the City of Moses Lake, bridges were damaged, though Crab Creek did not overflow its banks within the city. The channel through the city could have carried another 2 to 3 feet of water. The flood damaged both the Alder Street and State Highway 17 bridges by eroding the fill material and washing out the abutments. Floating ice aggravated the flooding by creating dams at the bridges and forcing backwater to inundate land adjacent to Crab Creek.

The February 1957 flood inundated virtually the entire town of Wilson Creek by approximately four to five feet of water, as Wilson Creek overtopped and breached the levee in place at the time, allowing 80 percent of its flow to pass though the business district. The current levee system is not sufficient to provide flood protection for the 1-percent-annualchance flood event. Residences and businesses were damaged extensively, streets were eroded, bridges were washed out, and large sections of the levee system were destroyed. The flooding was aggravated by the failure of Bennett's Dam, located about two miles upstream of town on Wilson Creek. The failure of this structure increased the peak flow on Wilson Creek by an estimated 5,000 cubic feet per second (cfs). Ice and debris jams aggravated flooding as well.

Dry Creek

Several floods have occurred on Dry Creek at Ephrata since 1900. The three largest floods occurred in 1901, 1920, and 1948. The 1901 flood was caused by rain combined with snowmelt; the 1920 and 1948 floods were caused by severe thunderstorms. No estimates were made of the peak discharges for the 1901 and 1920 floods. The 1948 flood was reported to be the worst flood in the history of Ephrata, with a peak discharge of 3,080 cfs estimated by slope-area measurements. The estimated recurrence interval is 75 years. This flood was the result of a severe thunderstorm on the evening of May 27. An 8-foot wall of water roared down Dry Creek and broke through the existing diversion dikes at First Avenue Northwest and G Street Northwest, causing extensive damage. A 60-block area of the city was inundated by water and silt. Basements, streets, lawns, and most of the downtown offices at street level were flooded. Storm sewers that were obstructed by silt aggravated the flooding.

13.2.1 Past Events

The Columbia River has a history of flood events. Floods have occurred in 1894, 1948, 1964,1974, and 1979. However, since several dams have been erected in the Columbia River, the likelihood of river flooding occurring has been drastically reduced. Significant past flood events within the planning area are shown in table 13-2.

TABLE 13-2.
GRANT COUNTY FLOOD EVENTS

Date	Declaration #	Type of event	Estimated Damage[a]
1904-(Quincy)	NA	Flooding (First flooding of record on Crab Creek)	
1948	NA	Flooding due to lack of canal in Ephrata and Sagebrush Flats	
March 1957	70	Flood	
March 1963	146	Flood	
1964/1965	NA	Flood - Wilson Creek damaged bridge	
1973	NA	Flood in Dry Creek Canyon.	
June 24, 1991	NA	Flash Flooding	50,000
Dec 1996-Feb 1997	1159	Flood, Ice, Wind, Snow, Landslides (below Priest Rapids Dam due to snowmelt)	
July 31, 1998	NA	Flood	40,000
June 6, 2009		Flash flood	10,000

a. Data obtained from Spatial Hazard Events and Losses Database for the United States (SHELDUS)
N/A = Information is not available

13.2.2 Location

The major floods in Grant County have resulted from intense weather rainstorms between December and February. The flooding that has occurred in portions of the county has been extensively documented by gage records, high water marks, damage surveys and personal accounts. This documentation was the basis for the June 16, 2009 FIRMs generated by FEMA for Grant County.

13.2.3 Frequency

Grant County experiences episodes of river flooding almost every winter. Large floods that can cause property damage typically occur every three to seven years. Urban portions of the county annually experience nuisance flooding related to drainage issues.

13.2.4 Severity

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak discharges; Table 13-3 lists peak flows used by FEMA to map the floodplains of Grant County.

**TABLE 13-3.
SUMMARY OF PEAK DISCHARGES WITHIN GRANT COUNTY**

Source/Location	Drainage Area (Mi^2)	Discharge (cubic feet/second)			
		10-Year	50-Year	100-Year	500-Year
Crab Creek					
At USGS gaging station, 3 miles north of Moses Lake	2,009	2,960	8,800	13,200	31,000
Downstream of confluence with Rocky Coulee Wasteway	2,306	3,300	9,450	14,100	32,700
Upstream of confluence of Wilson Creek	1,338	4.800	10,100	12,600	18,600
Downstream of confluence with Wilson Creek	1,765	7,170	14,570	18,170	27,600
Dry Creek					
At West Canal Crossing	26.8	1,080	2,550	3,500	7,000
Wilson Creek					
At confluence with Crab Creek	427	3,670	7,470	9,370	14,200

13.2.5 Warning Time

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for floods can be between 36 and 72 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.

Flooding is more likely to occur due to a rain storm when the soil is already wet and/or streams are already running high from recent previous rains (conditions already in place when a storm begins are called “antecedent conditions”). Grant County utilizes the National Weather Service’s terminology and alert broadcasts, as follows:

- **Flood Potential:** An event could develop in the next 36 to 72 hours with the possibility of life-threatening situations if caution is not exercised.
- **Flood Watch:** A flood is possible but not certain within the next 12 to 36 hours. Be alert, monitor NOAA Weather Radio and be prepared to take immediate action ifthe watch is upgraded to a warning.
- **Flood Warning:** A severe or dangerous weather event is occurring or is imminent in the next 12 hours. **TAKE ACTION NOW!!**

Based on the Weather Service’s predictions, Grant County responds accordingly.

13.3. SECONDARY HAZARDS

The most problematic secondary hazard for flooding is bank erosion, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers or storm sewers.

13.4. CLIMATE CHANGE IMPACTS

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example historical data are used for flood forecasting models and to forecast snowmelt runoff for water supply. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Going forward, model calibration or statistical relation development must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted. Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain area to contribute to peak storm runoff. High frequency flood event s (e.g. 10 - year floods) in particular will likely increase with a changing climate. Along with reductions in the amount of the snowpack and accelerated snowmelt, scientists project greater storm intensity, resulting in more direct runoff and flooding. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

As hydrology changes, what is currently considered a 100-year flood may strike more often, leaving many communities at greater risk. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams, floodways, bypass channels and levees, as well as the design of local sewers and storm drains.

13.5. EXPOSURE

The Level 2 HAZUS-MH protocol was used to assess the risk and vulnerability to flooding in the planning area. The model used census data at the block level and FEMA floodplain data, which has a level of accuracy acceptable for planning purposes. Where possible, the HAZUS-MH default data was enhanced using local GIS data from county, state and federal sources.

13.5.1 Population

Population counts of those living in the floodplain in the planning area were generated by analyzing buildings that intersect with the 100 and 500-year floodplains identified on DFIRMs. GIS estimated the number of buildings within the floodplain, and then estimated the total population by multiplying the number of residential structures by the average Grant County household size of 3 persons per household.

Using this approach, it was estimated that the exposed population for the entire county is 2,800 within the 100-year floodplain (3.1 percent of the total county population) and 2,865 within the 500-year floodplain (3.2 percent of the total). For the unincorporated portions of the county, it is estimated that the exposed population is 678 within the 100-year floodplain and 700 within the 500-year floodplain.

13.5.2 Property

Structures in the Floodplain

Table 13-4 and Table **13-5** summarize the total area and number of structures in the floodplain by municipality. The GIS model determined that there are 1,153structures within the 100-year floodplain and 1,172 structures within the 500-year floodplain. In the 100-year floodplain, about 28 percent of these structures are in unincorporated areas.

Table 13-4.
Area and Structures Within the 100-Year Floodplain

	Area in Floodplain (Acres)	Number of Structures in Floodplain Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	**Total**
Coulee City	31	0	0	0	0	0	0	0	**0**
Electric City	5	0	0	0	0	0	0	0	**0**
Ephrata	515	602	1	0	87	0	0	0	**690**
George	0	0	0	0	0	0	0	0	**0**
Grand Coulee	95	0	0	0	0	0	0	0	**0**
Hartline	11	0	0	0	0	0	0	0	**0**
Krupp	0	0	0	0	0	0	0	0	**0**
Mattawa	0	0	0	0	0	0	0	0	**0**
Moses Lake	1,388	34	0	0	1	0	0	0	**35**
Quincy	2	1	0	0	0	0	0	0	**1**
Royal City	0	0	0	0	0	0	0	0	**0**
Soap Lake	6	0	0	0	0	0	0	0	**0**
Warden	1	0	0	0	0	0	0	0	**0**
Wilson Creek	223	80	0	0	28	0	0	0	**108**
Unincorporated	119,006	226	0	0	93	0	0	0	**319**
Total	**121,283**	**943**	**1**	**0**	**209**	**0**	**0**	**0**	**1,153**

Table 13-5 Area and Structures Within the 500-Year Floodplain									
	Area in Floodplain	Number of Structures in Floodplain							
	(Acres)	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	**Total**
Coulee City	31	0	0	0	0	0	0	0	**0**
Electric City	5	0	0	0	0	0	0	0	**0**
Ephrata	515	602	1	0	87	0	0	0	**690**
George	0	0	0	0	0	0	0	0	**0**
Grand Coulee	95	0	0	0	0	0	0	0	**0**
Hartline	11	0	0	0	0	0	0	0	**0**
Krupp	0	0	0	0	0	0	0	0	**0**
Mattawa	0	0	0	0	0	0	0	0	**0**
Moses Lake	1,419	34	0	0	1	0	0	0	**35**
Quincy	2	1	0	0	0	0	0	0	**1**
Royal City	0	0	0	0	0	0	0	0	**0**
Soap Lake	6	0	0	0	0	0	0	0	**0**
Warden	1	0	0	0	0	0	0	0	**0**
Wilson Creek	228	85	0	0	30	0	0	0	**115**
Unincorporated	119,088	233	0	0	98	0	0	0	**331**
Total	**121,401**	**955**	**1**	**0**	**216**	**0**	**0**	**0**	**1,172**

Exposed Value

Table 13-6 summarizes the estimated value of exposed buildings in the planning area. This methodology estimated $268.6 million worth of building-and-contents exposure to the 100-year flood, representing 3.5 percent of the total assessed value of the planning area.

Table 13-6. Value of Exposed Buildings Within 100-Year Floodplain				
	Estimated Flood Exposure			% of Total
	Structure	Contents	**Total**	Assessed Value
Coulee City	0	0	**0**	0.00%
Electric City	0	0	**0**	0.00%
Ephrata	93,127,000	79,959,000	**173,086,000**	29.28%
George	0	0	**0**	0.00%

Grand Coulee	0	0	**0**	0.00%
Hartline	0	0	**0**	0.00%
Krupp	0	0	**0**	0.00%
Mattawa	0	0	**0**	0.00%
Moses Lake	6,458,000	5,165,000	**11,623,000**	0.73%
Quincy	49,000	39,000	**88,000**	0.02%
Royal City	0	0	**0**	0.00%
Soap Lake	0	0	**0**	0.00%
Warden	0	0	**0**	0.00%
Wilson Creek	5,950,000	4,977,000	**10,927,000**	66.26%
Unincorporated	39,706,000	33,165,000	**72,871,000**	1.65%
Total	**145,290,000**	**123,305,000**	**268,595,000**	**3.53%**

13.5.3 Critical Facilities and Infrastructure

Tables 13 -9 and 13-10 summarize the critical facilities and infrastructure in the 100-year floodplain of Grant County.

Tier II Facilities

Tier II facilities are those that use or store materials that can harm the environment if damaged by a flood. No businesses in the 100-year floodplain report having Tier II hazardous materials. During a flood event, containers holding these materials can rupture and leak into the surrounding area, having a disastrous effect on the environment as well as residents.

Utilities and Infrastructure

It is important to determine who may be at risk if infrastructure is damaged by flooding. Roads or railroads that are blocked or damaged can isolate residents and can prevent access throughout the county, including for emergency service providers needing to get to vulnerable populations or to make repairs. Bridges washed out or blocked by floods or debris also can cause isolation. Water and sewer systems can be flooded or backed up, causing health problems. Underground utilities can be damaged. Dikes can fail or be overtopped, inundating the land that they protect. The following sections describe specific types of critical infrastructure.

Table 13-9.
Grant County Critical Facilities In The 100-Year Floodplain

City	Medical and Health	Government Functions	Protective Functions	Schools	Hazmat	Other Critical Functions	**Total**
Coulee City	0	0	0	0	0	0	**0**
Electric City	0	0	0	0	0	0	**0**
Ephrata	1	1	2	5		6	**15**
George	0	0	0	0	0	0	**0**
Grand Coulee	0	0	0	0	0	0	**0**

Hartline	0	0	0	0	0	0	**0**
Krupp	0	0	0	0	0	0	**0**
Mattawa	0	0	0	0	0	0	**0**
Moses Lake	0	0	0	0	0	0	**0**
Quincy	0	0	0	0	0	0	**0**
Royal City	0	0	0	0	0	0	**0**
Soap Lake	0	0	0	0	0	0	**0**
Warden	0	0	0	0	0	0	**0**
Wilson Creek	0	0	0	0	0	0	**0**
Unincorporated	0	0	0	0	0	0	**0**
Total	**1**	**1**	**2**	**5**	**0**	**6**	**15**

Table 13-10.
Grant County Critical Infrastructure In The 100-Year Floodplain

City	Bridges	Water Supply	Wastewater	Power	Communications	Other	**Total**
Coulee City	0	0	0	0	0	0	**0**
Electric City	0	0	0	0	0	0	**0**
Ephrata	0	0	0	1	1	0	**2**
George	0	0	0	0	0	0	**0**
Grand Coulee	0	0	0	0	0	0	**0**
Hartline	0	0	0	0	0	0	**0**
Krupp	0	0	0	0	0	0	**0**
Mattawa	0	0	0	0	0	0	**0**
Moses Lake	4	0	0	0	0	0	**4**
Quincy	0	0	0	0	0	0	**0**
Royal City	0	0	0	0	0	0	**0**
Soap Lake	0	0	0	0	0	0	**0**
Warden	0	0	0	0	0	0	**0**
Wilson Creek	1	0	0	0	0	0	**1**
Unincorporated	25	0	1	2	1	10	**39**
Total	**30**	**0**	**1**	**3**	**2**	**10**	**46**

Roads

The following major roads in Grant County pass through the 100-year floodplain and thus are exposed to flooding:

- SR 155
- SR 17
- SR 243
- SR 28

- SR 170
- SR 24
- US 2
- US 90

Some of these roads are built above the flood level, and others function as levees to prevent flooding. Still, in severe flood events these roads can be blocked or damaged, preventing access to some areas.

Bridges

Flooding events can significantly impact road bridges. These are important because often they provide the only ingress and egress to some neighborhoods. An analysis showed that there are 30 bridges that are in or cross over the 100-year floodplain.

Water and Sewer Infrastructure

Water and sewer systems can be affected by flooding. Floodwaters can back up drainage systems, causing localized flooding. Culverts can be blocked by debris from flood events, also causing localized urban flooding. Floodwaters can get into drinking water supplies, causing contamination. Sewer systems can be backed up, causing wastewater to spill into homes, neighborhoods, rivers and streams.

Environment

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, with human development factored in, flooding can impact the environment in negative ways. Migrating fish can wash into roads or over dikes into flooded fields, with no possibility of escape. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments and levees, and logjams from timber harvesting can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

13.6. VULNERABILITY

Many of the areas exposed to flooding may not experience serious flooding or flood damage. This section describes vulnerabilities in terms of population, property, infrastructure and environment.

13.6.1 Population

HAZUS estimated that a 100-year flood could displace up to 1,678 people, with 1,195 of those people needing short-term shelter.

13.6.2 Property

HAZUS-MH calculates losses to structures from flooding by looking at depth of flooding and type of structure. Using historical flood insurance claim data, HAZUS-MH estimates the percentage of damage to structures and their contents by applying established damage functions to an inventory. For this analysis, local data on facilities was used instead of the default inventory data provided with HAZUS-MH.

The analysis is summarized in Table 13-11 for the 100-year flood event. It is estimated that there would be up to $52.6 million of flood loss from a 100-year flood event in the planning area. This represents 19.6 percent of the total exposure to the 100-year flood and 0.7 percent of the total assessed value for the county.

Table 13-11. Estimated Flood Loss For The 100-Year Flood Event				
	Estimated Flood Loss			% of Total
	Structure	Contents	**Total**	Assessed Value
Coulee City	0	0	**0**	0.00%
Electric City	0	0	**0**	0.00%
Ephrata	7,468,000	9,704,000	**17,172,000**	2.91%
George	0	0	**0**	0.00%
Grand Coulee	0	0	**0**	0.00%
Hartline	0	0	**0**	0.00%
Krupp	0	0	**0**	0.00%
Mattawa	0	0	**0**	0.00%
Moses Lake	2,414,000	3,085,000	**5,499,000**	0.35%
Quincy	0	0	**0**	0.00%
Royal City	0	0	**0**	0.00%
Soap Lake	0	0	**0**	0.00%
Warden	0	0	**0**	0.00%
Wilson Creek	843,000	978,000	**1,821,000**	11.04%
Unincorporated	13,301,000	14,864,000	**28,165,000**	0.64%
Total	**24,026,000**	**28,631,000**	**52,657,000**	**0.69%**

National Flood Insurance Program

Table 13-12 lists flood insurance statistics that help identify vulnerability in Grant County. Eight communities in the planning area, including unincorporated Grant County participate in the NFIP, with 361 flood insurance policies providing $64.186 million in insurance coverage. According to FEMA statistics, 14 flood insurance claims were paid between January 1, 1978 and February 29, 2012, for a total of $13,300, an average of $971 per claim.

Properties constructed after a FIRM has been adopted are eligible for reduced flood insurance rates. Such structures are less vulnerable to flooding since they were constructed after regulations and codes were adopted to decrease vulnerability. Properties built before a FIRM is adopted are more vulnerable to flooding because they do not meet code or are located in hazardous areas. The first FIRMs in Grant County were available in 1988.

**TABLE 13-12.
FLOOD INSURANCE STATISTICS FOR GRANT COUNTY**

Jurisdiction	Date of Entry Initial FIRM Effective Date	# of Flood Insurance Policies as of 2/29/2012	Insurance In Force	Total Annual Premium	Claims, 11/1978 to 2/29/2012	Value of Claims paid, 11/1988 to 2/29/2012
Coulee	2/18/09	0	$0	$0	0	$0
Ephrata	9/30/88	283	$47,499,000	$310,418	12	$9,100.42
Moses Lake	1/5/89	17	$4,234,900	$8,462	1	$1,776.84
Hartline	3/4/85	0	$0	$0	0	$0
Quincy	12/18/09	1	$152,500	$813	0	$0
Warden	12/18/09	0	$0	$0	0	$0
Wilson Creek	7/15/1988	18	$1,821,900	$13,896	0	$0
Unincorporated	9/30/88	42	$10,478,500	$21,805	1	$2,423.42
Total		**361**	**$64,186,800**	**$355,394**	**14**	**$13,300.68**

The following information from flood insurance statistics is relevant to reducing flood risk:

- The use of flood insurance in Grant County is well below the national average. Only 29.5 percent of insurable buildings in the county are covered by flood insurance. According to an NFIP study, about 49 percent of single-family homes in special flood hazard areas are covered by flood insurance nationwide.
- The average claim paid in the planning area represents less than 1 percent of the 2011 average assessed value of structures in the floodplain.
- The percentage of policies and claims outside a mapped floodplain suggests that not all of the flood risk in the planning area is reflected in current mapping. Based on information from the NFIP, 88.5 percent of policies in the planning area are on structures within an identified SFHA, and 11.5 percent are for structures outside such areas. Of total claims paid, 12.2 percent were for properties outside an identified 100-year floodplain.

Repetitive Loss

A repetitive loss property is defined by FEMA as an NFIP-insured property that has experienced any of the following since 1978, regardless of any changes in ownership:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period
- Three or more paid losses that equal or exceed the current value of the insured property.

Repetitive loss properties make up only 1 to 2 percent of flood insurance policies in force nationally, yet they account for 40 percent of the nation's flood insurance claim payments. In 1998, FEMA reported that the NFIP's 75,000 repetitive loss structures have already cost $2.8 billion in flood insurance payments and that numerous other flood-prone structures remain in the floodplain at high risk. The government has instituted programs encouraging communities to identify and mitigate the causes of repetitive losses. A recent report on repetitive losses by the National Wildlife Federation found that 20 percent of these properties are outside any mapped 100-year floodplain. The key identifiers for repetitive loss properties are the existence of flood insurance policies and claims paid by the policies.

FEMA-sponsored programs, such as the CRS, require participating communities to identify repetitive loss areas. A repetitive loss area is the portion of a floodplain holding structures that FEMA has identified as meeting the definition of repetitive loss. Identifying repetitive loss areas helps to identify structures that are at risk but are not on FEMA's list of repetitive loss structures because no flood insurance policy was in force at the time of loss. According to FEMA region, there are no identified repetitive loss properties within the planning area as of May 1, 2012.

13.6.3 Critical Facilities and Infrastructure

HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves to estimate the percent of damage to the building and contents of critical facilities, HAZUS-MH correlates these estimates into an estimate of functional down-time (the estimated time it will take to restore a facility to 100 percent of its functionality). This helps to gauge how long the planning area could have limited usage of facilities deemed critical to flood response and recovery. The HAZUS critical facility results are as follows:

- **100-year flood event**—On average, critical facilities would receive 8.25 percent damage to the structure and 34.6 percent damage to the contents during a 100-year flood event. The estimated time to restore these facilities to 100 percent of their functionality is 509 days.

13.6.4 Environment

The environment vulnerable to flood hazard is the same as the environment exposed to the hazard. Loss estimation platforms such as HAZUS-MH are not currently equipped to measure environmental impacts of flood hazards. The best gauge of vulnerability of the environment would be a review of damage from past flood events. Loss data that segregates damage to the environment was not available at the time of this plan. Capturing this data from future events could be beneficial in measuring the vulnerability of the environment for future updates.

13.7. FUTURE TRENDS

The county has experienced moderate growth ranging from .004% in 1981 to a high of 5.02% in 1995. Economic problems in the past have impacted growth in the County, with some area experiencing negative growth. Grant County and its planning partners are optimistic that marginal, sustained growth will return to the county as the state and national economies strengthen.

Grant County and its planning partner cities are subject to the provisions of the Washington GMA, which regulates identified critical areas. County critical areas regulations include frequently flooded areas, defined as the FEMA 100-year mapped floodplain. The GMA establishes programs to monitor the densities at which commercial, residential and industrial development occurs under local GMA comprehensive plans and development regulations.

As participants in the NFIP, Grant County and the partner cities have adopted flood damage prevention ordinances pursuant to the participation requirements. While these ordinances do not prohibit new development within the floodplain, they include new development provisions that account for the risk inherent to the floodplain.

The combination of the GMA provisions, critical areas regulations and NFIP flood damage prevention provisions equips the municipal planning partners with adequate tools to address new development in the floodplain. As pressures mount for growth into areas with flood risk, these tools could be enhanced with higher regulatory standards to increase the level of risk reduction on new development.

13.8. SCENARIO

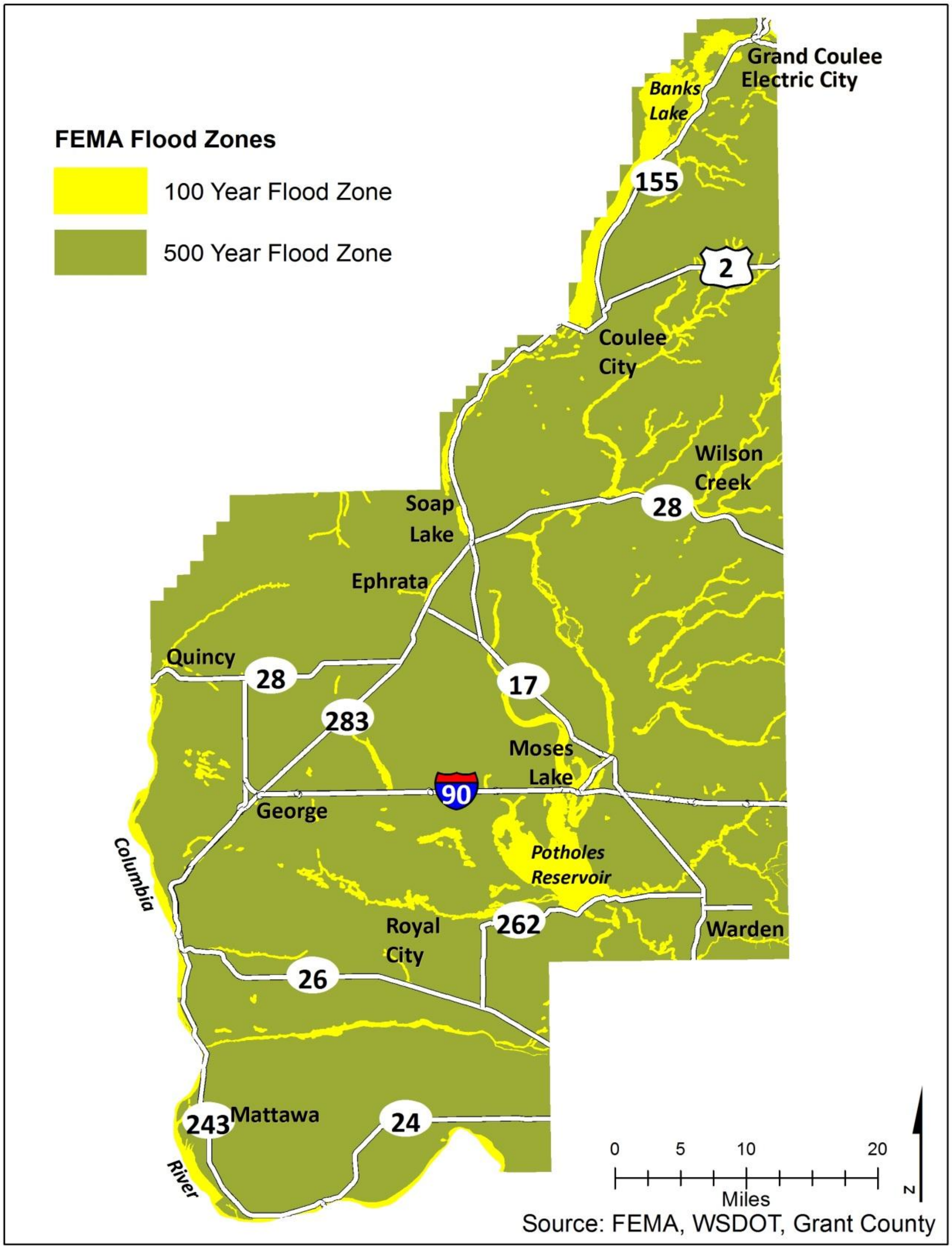
The primary water courses in Grant County have the potential to flood at irregular intervals, generally in response to a succession of intense winter rainstorms. Storm patterns of warm, moist air usually occur between early October and April. A series of such weather events can cause severe flooding in the planning area. The worst-case scenario is a series of storms that flood numerous drainage basins in a short time. This could overwhelm the response and floodplain management capability within the planning area. Major roads could be blocked, preventing critical access for many residents and critical functions. High in-channel flows could cause water courses to scour, possibly washing out roads and creating more isolation problems. In the case of multi-basin flooding, the County would not be able to make repairs quickly enough to restore critical facilities and infrastructure.

13.9. ISSUES

The planning team has identified the following flood-related issues relevant to the planning area:

- The extent of the flood-protection currently provided by flood control facilities (dams, dikes and levees) is not known due to the lack of an established national policy on flood protection standards.
- Older levees are subject to failure or do not meet current building practices for flood protection.
- The risk associated with the flood hazard overlaps the risk associated with other hazards such as earthquake, landslide and fishing losses. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- How will potential climate change impact flood conditions in Grant County?
- More information is needed on flood risk to support the concept of risk-based analysis of capital projects.
- There needs to be a sustained effort to gather historical damage data, such as high water marks on structures and damage reports, to measure the cost-effectiveness of future mitigation projects.
- Ongoing flood hazard mitigation will require funding from multiple sources.
- There needs to be a coordinated hazard mitigation effort between jurisdictions affected by flood hazards in the county.
- Floodplain residents need to continue to be educated about flood preparedness and the resources available during and after floods.
- The concept of residual risk should be considered in the design of future capital flood control projects and should be communicated with residents living in the floodplain.
- The promotion of flood insurance as a means of protecting private property owners from the economic impacts of frequent flood events should continue.

- Existing floodplain-compatible uses such as agricultural and open space need to be maintained. There is constant pressure to convert these existing uses to more intense uses within the planning area during times of moderate to high growth.
- The economy affects a jurisdiction's ability to manage its floodplains. Budget cuts and personnel losses can strain resources needed to support floodplain management.



Map 13-1: Floodplain Map: 2009 FEMA Flood Data

CHAPTER 14.
LANDSLIDE

14.1. GENERAL BACKGROUND

> **DEFINITIONS**
>
> **Landslide**—The sliding movement of masses of loosened rock and soil down a hillside or slope. Such failures occur when the strength of the soils forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.
>
> **Mass Movement—**A collective term for landslides, debris flows, falls and sinkholes.
>
> **Mudslide (or Mudflow or Debris Flow)—**A river of rock, earth, organic matter and other materials saturated with water.

A landslide is a mass of rock, earth or debris moving down a slope. Landslides may be minor or very large, and can move at slow to very high speeds. They can be initiated by storms, earthquakes, fires, volcanic eruptions or human modification of the land.

Mudslides (or mudflows or debris flows) are rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil's reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud or "slurry." A debris flow or mudflow can move rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars and anything else in its path. Although these slides behave as fluids, they pack many times the hydraulic force of water due to the mass of material included in them. Locally, they can be some of the most destructive events in nature.

All mass movements are caused by a combination of geological and climate conditions, as well as the encroaching influence of urbanization. Vulnerable natural conditions are affected by human residential, agricultural, commercial and industrial development and the infrastructure that supports it.

14.2. HAZARD PROFILE

Landslides are caused by one or a combination of the following factors: change in slope of the terrain, increased load on the land, shocks and vibrations, change in water content, groundwater movement, frost action, weathering of rocks, and removing or changing the type of vegetation covering slopes. In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:

- A slope greater than 33 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable
- The presence or potential for snow avalanches
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments

- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Flows and slides are commonly categorized by the form of initial ground failure. Figure 14-1 through Figure 14-4 show common types of slides. The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, although they are less common than other types.

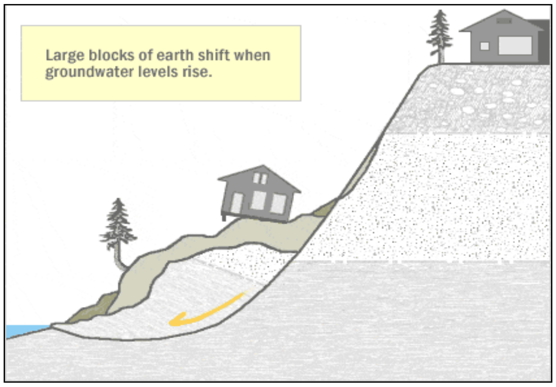


Figure 14-1. Deep Seated Slide

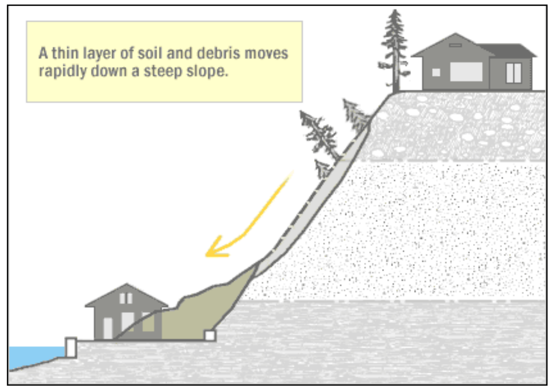


Figure 14-2. Shallow Colluvial Slide

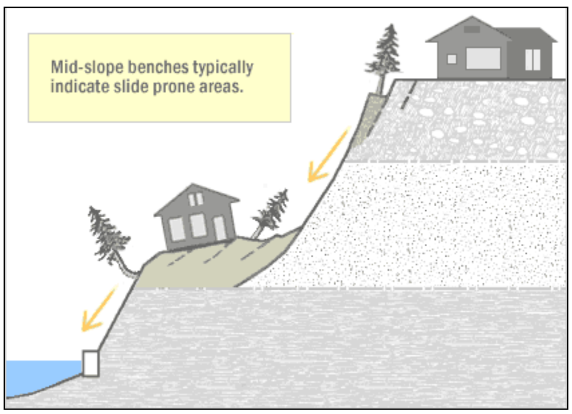


Figure 14-3. Bench Slide

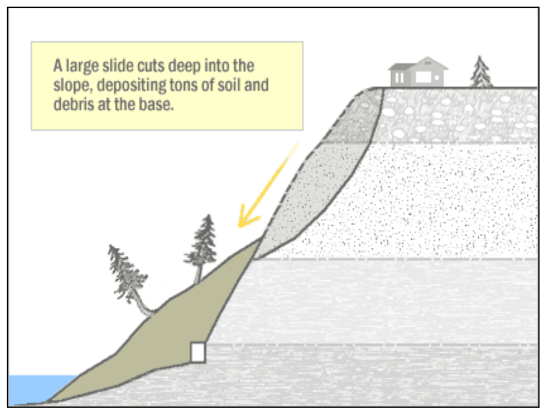


Figure 14-4. Large Slide

Slides and earth flows can pose serious hazard to property in hillside terrain. They tend to move slowly and thus rarely threaten life directly. When they move—in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support—they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, breaking of underground pipes, or overriding of downslope property and structures.

14.2.1 Past Events

There is little recorded information regarding landslides in Grant County. Those that have occurred have been the result of flooding, breaks in irrigation canals or in the volcanic lava formation along the Columbia River and Coulee's. One area near Grand Coulee Dam has been subject to earth movement due to vibrations from the Dam's operations causing some structure problems to buildings and fuel tanks.

According to the Spatial Hazard Events and Losses Database for the United States (SHELDUS), two slides are reported to have occurred within Grant County. The first occurred on January 26, 1965, causing $12,820 worth of property damage (1965 value). The second occurred on December 18, 1972, which caused $18,518 worth of damages (1972 value). There are two additional events which occurred within Grant County: July 20, 1996 in the Grand Coulee Dam area; damage extent not reported. The second event occurred in February 1999, within the City of Grand Coulee. Again, the extent of damages is unknown. There are no records in the County of fatalities attributed to mass movement. However, deaths have occurred across the west coast as a result of slides and slope collapses.

14.2.2 Location

The best available predictor of where movement of slides and earth flows might occur is the location of past movements. Past landslides can be recognized by their distinctive topographic shapes, which can remain in place for thousands of years. Most landslides recognizable in this fashion range from a few acres to several square miles. Most show no evidence of recent movement and are not currently active. A small proportion of them may become active in any given year, with movements concentrated within all or part of the landslide masses or around their edges.

The recognition of ancient dormant mass movement sites is important in the identification of areas susceptible to flows and slides because they can be reactivated by earthquakes or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of groundwater flow, these dormant sites are vulnerable to construction-triggered sliding.

Within Grant County, there are a number of areas that are in danger of landslides. Those would include the Columbia River areas, and Coulee's such as Bank's Lake area and the old Columbia River George between Soap Lake and Coulee City. The area at Grand Coulee Dam is also subject to slides during heavy rains.

14.2.3 Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildfires, so landslide frequency is often related to the frequency of these other hazards. In Grant County, landslides typically occur during and after major storms, so the potential for landslides largely coincides with the potential for sequential severe storms that saturate steep, vulnerable soils. Until better data is generated specifically for landslide hazards, this severe storm frequency is appropriate for the purpose of ranking risk associated with the landslide hazard.

14.2.4 Severity

Historically, landslides have been known to destroy property and infrastructure and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion. According to SHELDUS, the January 26, 1965 landslide caused an estimated $12,820 worth of property damage (1965 value). The second slide which occurred on December 18, 1972, caused $18,518 worth of damages (1972 value).

14.2.5 Warning Time

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current standard operating procedure is to monitor situations on a case-by-case basis, and respond after the event has occurred. Generally accepted warning signs for landslide activity include:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements or sidewalks
- Soil moving away from foundations
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels though rain is still falling or just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

14.3. SECONDARY HAZARDS

Landslides can cause several types of secondary effects, such as blocking access to roads, which can isolate residents and businesses and delay commercial, public and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

14.4. CLIMATE CHANGE IMPACTS

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.

14.5. EXPOSURE

14.5.1 Population

Population could not be examined by landslide hazard area because census block group areas do not coincide with the hazard areas. A population estimate was made using the structure count of buildings within the landslide hazard areas and applying the census value of 3 persons per household for Grant County. Using this approach, the estimated population living in the potential landslide risk area is 135. It should be noted that this approach could understate the exposure by as much as a factor of two, so it is reasonable to assume that the exposed population may be as high as 300, less than one percent of the total county population.

14.5.2 Property

Tables 14-1 and 14-2 show the number and assessed value of structures exposed to the landslide risk. There are 54 structures on parcels in the “15 to 30 Percent Slope” risk areas, with an estimated value of $11.5 million. There is one structure on parcels in the “Greater than 30 Percent Slope” risk area, with an estimated value of $138,000.

Table 14-1.

Grant County Structures in “15-30% Slope, Soft Soils” Risk Areas

Jurisdiction	Buildings Exposed	Assessed Value Structure	Contents	**Total**	% of AV
Coulee City	0	$0	$0	**$0**	0.0%
Electric City	2	$327,000	$262,000	**$589,000**	0.7%
Ephrata	0	$0	$0	**$0**	0.0%
George	0	$0	$0	**$0**	0.0%
Grand Coulee	25	$2,815,000	$2,312,000	**$5,127,000**	6.7%
Hartline	0	$0	$0	**$0**	0.0%
Krupp	0	$0	$0	**$0**	0.0%
Mattawa	0	$0	$0	**$0**	0.0%
Moses Lake	0	$0	$0	**$0**	0.0%
Quincy	0	$0	$0	**$0**	0.0%
Royal City	0	$0	$0	**$0**	0.0%
Soap Lake	0	$0	$0	**$0**	0.0%
Warden	0	$0	$0	**$0**	0.0%
Wilson Creek	0	$0	$0	**$0**	0.0%
Unincorporated	27	$3,142,000	$2,679,000	**$5,821,000**	0.1%
Total	**54**	**$6,284,000**	**$5,253,000**	**$11,537,000**	**0.2%**

Table 14-2.
Grant County Structures in "Greater than 30% Slope, Soft Soils" Risk Areas

	Buildings	Assessed Value			
Jurisdiction	Exposed	Structure	Contents	**Total**	% of AV
Coulee City	0	$0	$0	**$0**	0.00%
Electric City	0	$0	$0	**$0**	0.00%
Ephrata	0	$0	$0	**$0**	0.00%
George	0	$0	$0	**$0**	0.00%
Grand Coulee	0	$0	$0	**$0**	0.00%
Hartline	0	$0	$0	**$0**	0.00%
Krupp	0	$0	$0	**$0**	0.00%
Mattawa	0	$0	$0	**$0**	0.00%
Moses Lake	0	$0	$0	**$0**	0.00%
Quincy	0	$0	$0	**$0**	0.00%
Royal City	0	$0	$0	**$0**	0.00%
Soap Lake	0	$0	$0	**$0**	0.00%
Warden	0	$0	$0	**$0**	0.00%
Wilson Creek	0	$0	$0	**$0**	0.00%
Unincorporated	1	$77,000	$61,000	**$138,000**	0.00%
Total	**1**	**$77,000**	**$61,000**	**$138,000**	**0.00%**

14.5.3 Critical Facilities and Infrastructure

Grant County has no critical facilities exposed to steep slope hazard areas, but it is still possible for a significant amount of infrastructure to be exposed to mass movements:

- **Roads**—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.
- **Bridges**—Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.
- **Power Lines**—Power lines are generally elevated above steep slopes; but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.

14.5.4 Environment

Environmental problems as a result of mass movements can be numerous. Landslides that fall into streams may significantly impact fish and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolong periods of time due to landslides.

14.6. VULNERABILITY

14.6.1 Population

Due to the nature of census block group data, it is difficult to determine demographics of populations vulnerable to mass movements. In general, all of the estimated 300 persons exposed to higher risk landslide areas are considered to be vulnerable. Increasing population and the fact that many homes are built on view property atop or below bluffs and on steep slopes subject to mass movement, increases the number of lives endangered by this hazard.

14.6.2 Property

Although complete historical documentation of the landslide threat in Grant County is lacking, the landslides references suggest a minimal vulnerability to such hazards. The one factor which is significant is the impact of the dam operations itself causing landslides as a result of the vibration of machinery. The extent of the potential impact from this at present is unknown. Grant County is attempting to work with the Corps of Engineers to determine the impacts of this issue upon the Dam.

Loss estimations for the landslide hazard are not based on modeling utilizing damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 14-3 shows the general building stock loss estimates in all landslide risk areas.

14.6.3 Critical Facilities and Infrastructure

There are no critical facilities exposed to the steep slope hazard.

Several types of infrastructure are exposed to mass movements, including transportation, water and sewer and power infrastructure. Highly susceptible areas of the county include mountainous roadways and transportation infrastructure. At this time all infrastructure and transportation corridors identified as exposed to the landslide hazard are considered vulnerable until more information becomes available. The other major factor is the impact from the vibration of the machinery at Grand Coulee Dam, and the potential impact this may have on the structure of the dam. Until greater information can be gathered, the extent of impact from these landslides is unknown.

14.6.4 Environment

The environment vulnerable to landslide hazard is the same as the environment exposed to the hazard.

Table 14-3.
Estimated Building Losses Exposed to Landslide Risk Areas

Jurisdiction	Building Count	Assessed Value	10% Damage	30% Damage	50% Damage
Coulee City	0	$0	$0	$0	$0
Electric City	2	$589,000	$58,900	$176,700	$294,500
Ephrata	0	$0	$0	$0	$0
George	0	$0	$0	$0	$0
Grand Coulee	25	$5,127,000	$512,700	$1,538,100	$2,563,500
Hartline	0	$0	$0	$0	$0
Krupp	0	$0	$0	$0	$0
Mattawa	0	$0	$0	$0	$0
Moses Lake	0	$0	$0	$0	$0
Quincy	0	$0	$0	$0	$0
Royal City	0	$0	$0	$0	$0
Soap Lake	0	$0	$0	$0	$0
Warden	0	$0	$0	$0	$0
Wilson Creek	0	$0	$0	$0	$0
Unincorporated	28	$5,959,000	$595,900	$1,787,700	$2,979,500
Total	**55**	**$11,675,000**	**$1,167,500**	**$3,502,500**	**$5,837,500**

14.7. FUTURE TRENDS IN DEVELOPMENT

The county has experienced moderate growth over the past 10 years. However, economic problems in the past three years has impacted some areas, which experienced negative growth. Grant County and its planning partners are optimistic that sustained growth will continue as the state and national economies strengthen.

The County and its planning partners are equipped to handle future growth within landslide hazard areas. All municipal planning partners have general plans that address landslide risk areas in their safety elements. All partners have committed to linking their general plans to this hazard mitigation plan update. This will create an opportunity for wise land use decisions as future growth impacts landslide hazard areas.

Additionally, the State of Washington has adopted the International Building Code (IBC) by reference in its building code standards. The IBC includes provisions for geotechnical analyses in steep slope areas that have soil types considered susceptible to landslide hazards. These provisions assure that new construction is built to standards that reduce the vulnerability to landslide risk.

14.8. SCENARIO

Landslides in Grant County occur as a result of soil conditions that have been affected by severe storms, groundwater or human development. The worst-case scenario for landslide hazards in the planning area would generally correspond to a severe storm that had heavy rain and caused flooding. Landslides are most likely during the fall/winter timeframe, when the water tables are higher. After heavy rains from October to April, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. A short intense storm could cause saturated soil to move, resulting in landslides. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, poor drainage, a rising groundwater table and poor soil exacerbate hazardous conditions. This factor is of high concern within the dam areas as well, as Grant County has 64 dams countywide.

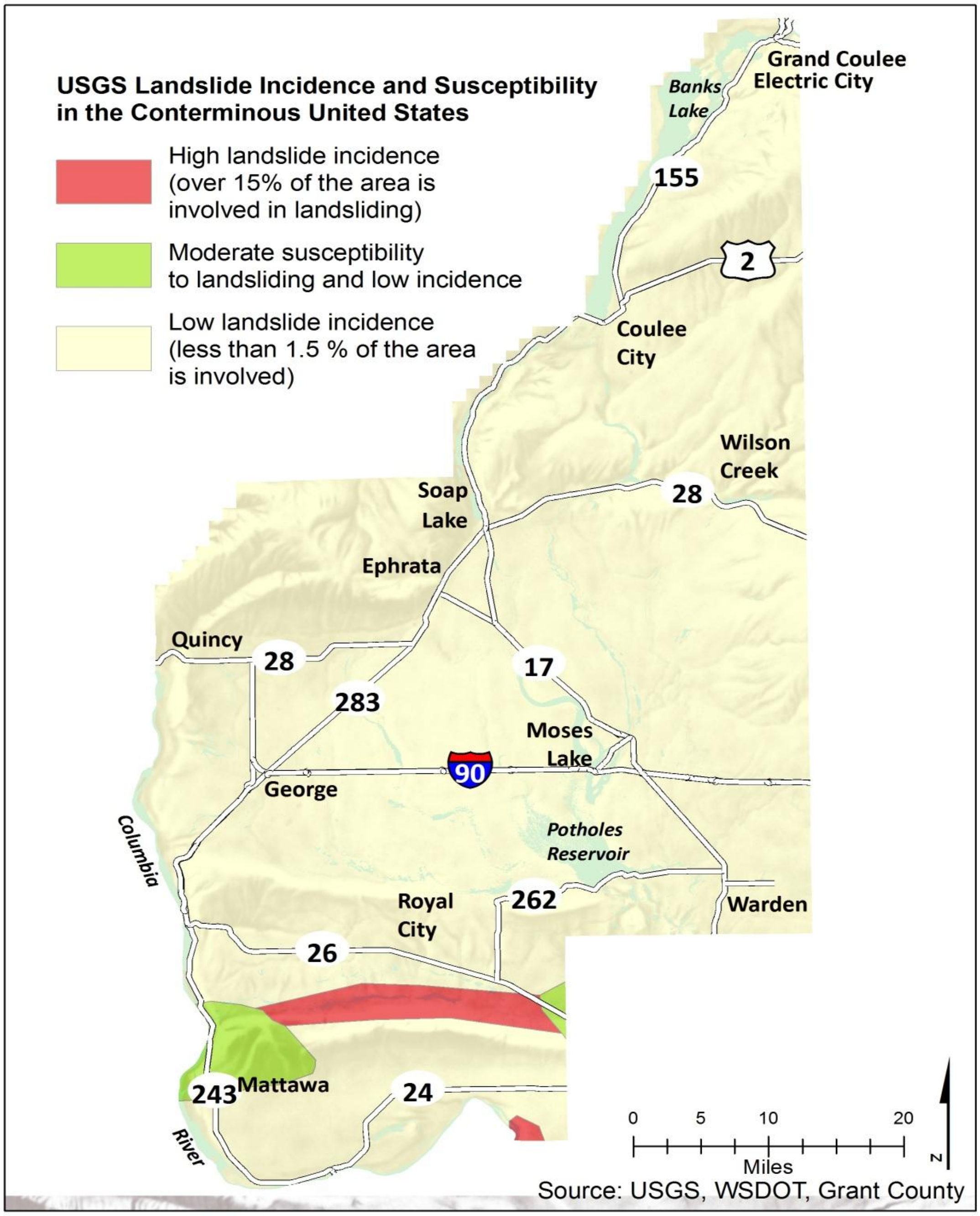
Mass movements are becoming more of a concern as development moves outside of city centers and into areas less developed in terms of infrastructure. Most mass movements would be isolated events affecting specific areas. It is probable that private and public property, including infrastructure, will be affected. Mass movements could affect dams and their supporting structures, and bridges that pass over landslide prone ravines and knock out rail service through the county. Road obstructions caused by mass movements could create isolation problems for some residents and businesses in sparsely developed areas. Property owners exposed to steep slopes may suffer damage to property or structures. Landslides carrying vegetation such as shrubs and trees may cause a break in utility lines, cutting off power and communication access to residents.

Continued heavy rains and flooding will complicate the problem further. As emergency response resources are applied to problems with flooding, it is possible they will be unavailable to assist with landslides occurring all over Grant County.

14.9. ISSUES

Important issues associated with landslides in Grant County include the following:

- The impact of slide damages around the dams within Grant County should be further studied, as the stability of the surrounding land and impacts from potential slides is unknown.
- There are existing homes in landslide risk areas throughout the County. The degree of vulnerability of these structures depends on the codes and standards the structures were constructed to. Information to this level of detail is not currently available.
- Future development could lead to more homes in landslide risk areas.
- Mapping and assessment of landslide hazards are constantly evolving. As new data and science become available, assessments of landslide risk should be reevaluated.
- The impact of climate change on landslides is uncertain. If climate change impacts atmospheric conditions, then exposure to landslide risks is likely to increase.
- Landslides may cause negative environmental consequences, including water quality degradation.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood and wildfire. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.



Map 14-1: USGS Landslide Incidence and Susceptibility

CHAPTER 15.
SEVERE (WINTER) STORMS

15.1. GENERAL BACKGROUND

Severe weather refers to any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. It includes thunderstorms, downbursts, tornadoes, waterspouts, snowstorms, ice storms, and dust storms.

Severe weather can be categorized into two groups: those that form over wide geographic areas are classified as general severe weather; those with a more limited geographic area are classified as localized severe weather. Severe weather, technically, is not the same as extreme weather, which refers to unusual weather events are at the extremes of the historical distribution for a given area.

Four types of severe weather events typically impact Grant County: thunderstorms, damaging winds, hail storms and flash flooding. There have been five recorded tornado/funnel cloud events with the County since 1950. Flooding issues associated with severe weather are discussed in Chapter 13. The other three types of severe weather common to Grant County are described in the following sections.

15.1.1 Thunderstorms

A thunderstorm is a rain event that includes thunder and lightning. A thunderstorm is classified as “severe” when it contains one or more of the following: hail with a diameter of three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or tornado.

Three factors cause thunderstorms to form: moisture, rising unstable air (air that keeps rising when disturbed), and a lifting mechanism to provide the disturbance. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise (hills or mountains can cause rising motion, as can the interaction of warm air and cold air or wet air and dry air) it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool and it condenses into a cloud. The cloud eventually grows upward into areas where the

DEFINITIONS

Freezing Rain—The result of rain occurring when the temperature is below the freezing point. The rain freezes on impact, resulting in a layer of glaze ice up to an inch thick. In a severe ice storm, an evergreen tree 60 feet high and 30 feet wide can be burdened with up to six tons of ice, creating a threat to power and telephone lines and transportation routes.

Dust Storm/Dryland Farming – Since dryland farmers rely on rainfall to water crops, they engage in practices to maintain moisture in the soil. Such practices include leaving a field fallow for a year after harvesting, allowing buildup of water in the soil and covering the field with dry earth to seal in the underlying moisture. These practices make dryland agriculture susceptible to dust storms. This is a common method used in Eastern Washington, which is an arid region.

Heavy Snow—Snow accumulations of 4 inches in 12 hours or 6 inches in 24 hours in non-mountainous locations; or 8 inches in 12 hours or 12 inches in 24 hours in mountain areas.

Severe Local Storm—”Microscale” atmospheric systems, including tornadoes, thunderstorms, windstorms, ice storms and snowstorms. These storms may cause a great deal of destruction and even death, but their impact is generally confined to a small area. Typical impacts are on transportation infrastructure and utilities.

Thunderstorm—A storm featuring heavy rains, strong winds, thunder and lightning, typically about 15 miles in diameter and lasting about 30 minutes. Hail and tornadoes are also dangers associated with thunderstorms. Lightning is a serious threat to human life. Heavy rains over a small area in a short time can lead to flash flooding.

Tornado—Funnel clouds that generate winds up to 500 miles per hour. They can affect an area up to three-quarters of a mile wide, with a path of varying length. Tornadoes can come from lines of cumulonimbus clouds or from a single storm cloud. They are measured using the Fujita Scale, ranging from F0 to F5.

Windstorm—A storm featuring violent winds. Southwesterly winds are associated with strong storms moving onto the coast from the Pacific Ocean. Southern winds parallel to the coastal mountains are the strongest and most destructive winds. Windstorms tend to damage ridgelines that face into the winds.

Winter Storm—A storm having significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation.

temperature is below freezing. Some of the water vapor turns to ice and some of it turns into water droplets. Both have electrical charges. Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up enough, they are discharged in a bolt of lightning, which causes the sound waves we hear as thunder. Thunderstorms have three stages (see Figure 15-1):

- The *developing stage* of a thunderstorm is marked by a cumulus cloud that is being pushed upward by a rising column of air (updraft). The cumulus cloud soon looks like a tower (called towering cumulus) as the updraft continues to develop. There is little to no rain during this stage but occasional lightning. The developing stage lasts about 10 minutes.
- The thunderstorm enters the *mature stage* when the updraft continues to feed the storm, but precipitation begins to fall out of the storm, and a downdraft begins (a column of air pushing downward). When the downdraft and rain-cooled air spread out along the ground, they form a gust front, or a line of gusty winds. The mature stage is the most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes. The storm occasionally has a black or dark green appearance.
- Eventually, a large amount of precipitation is produced and the updraft is overcome by the downdraft beginning the *dissipating stage*. At the ground, the gust front moves out a long distance from the storm and cuts off the warm moist air that was feeding the thunderstorm. Rainfall decreases in intensity, but lightning remains a danger.

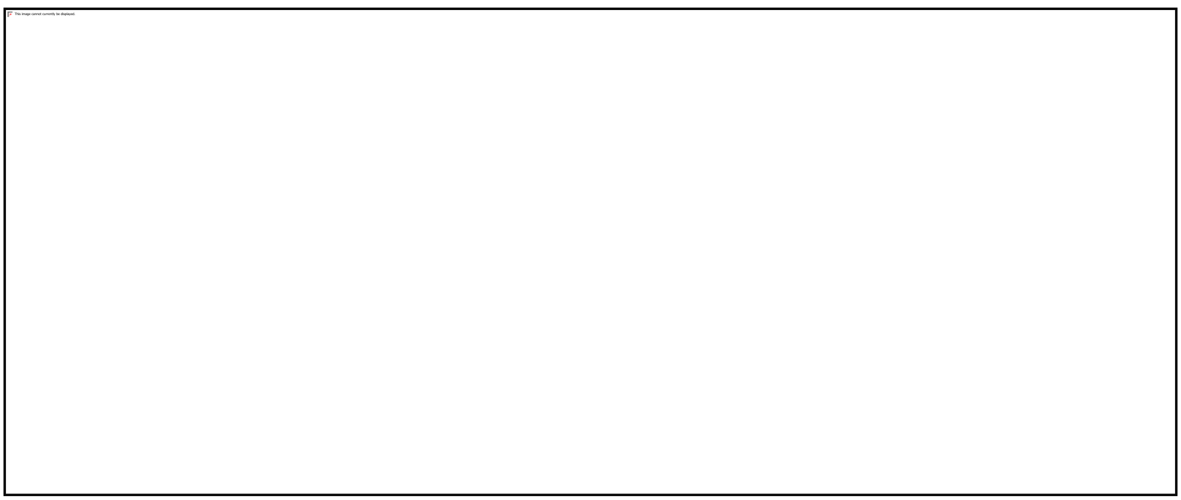


Figure 15-1. The Thunderstorm Life Cycle

There are four types of thunderstorms:

- **Single-Cell Thunderstorms—**Single-cell thunderstorms usually last 20 to 30 minutes. A true single-cell storm is rare, because the gust front of one cell often triggers the growth of another. Most single-cell storms are not usually severe, but a single-cell storm can produce a brief severe weather event. When this happens, it is called a pulse severe storm.
- **Multi-Cell Cluster Storm—**A multi-cell cluster is the most common type of thunderstorm. The multi-cell cluster consists of a group of cells, moving as one unit, with each cell in a different phase of the thunderstorm life cycle. Mature cells are usually found at the center of the cluster and dissipating cells at the downwind edge. Multi-cell cluster storms can produce moderate-size hail, flash floods and weak

tornadoes. Each cell in a multi-cell cluster lasts only about 20 minutes; the multi-cell cluster itself may persist for several hours. This type of storm is usually more intense than a single cell storm.

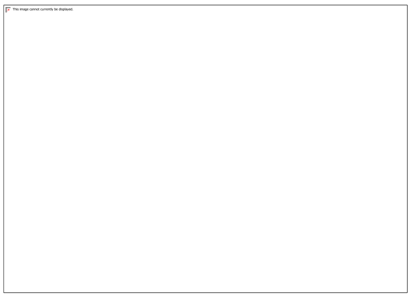
- **Multi-Cell Squall Line—**A multi-cell line storm, or squall line, consists of a long line of storms with a continuous well-developed gust front at the leading edge. The line of storms can be solid, or there can be gaps and breaks in the line. Squall lines can produce hail up to golf-ball size, heavy rainfall, and weak tornadoes, but they are best known as the producers of strong downdrafts. Occasionally, a strong downburst will accelerate a portion of the squall line ahead of the rest of the line. This produces what is called a bow echo. Bow echoes can develop with isolated cells as well as squall lines. Bow echoes are easily detected on radar but are difficult to observe visually.
- **Super-Cell Storm—**A super-cell is a highly organized thunderstorm that poses a high threat to life and property. It is similar to a single-cell storm in that it has one main updraft, but the updraft is extremely strong, reaching speeds of 150 to 175 miles per hour. Super-cells are rare. The main characteristic that sets them apart from other thunderstorms is the presence of rotation. The rotating updraft of a super-cell (called a mesocyclone when visible on radar) helps the super-cell to produce extreme weather events, such as giant hail (more than 2 inches in diameter), strong downbursts of 80 miles an hour or more, and strong to violent tornadoes.

Figure 15-2: Dissipating mammatus clouds following a thunderstorm (Source: Tetra Tech)

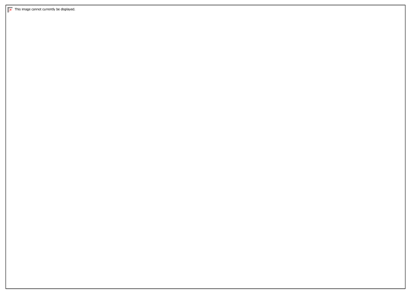
15.1.2 Damaging Winds

Damaging winds are classified as those exceeding 60 mph. Damage from such winds accounts for half of all severe weather reports in the lower 48 states and is more common than damage from tornadoes. Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles. There are nine types of damaging winds reviewed during the planning process.

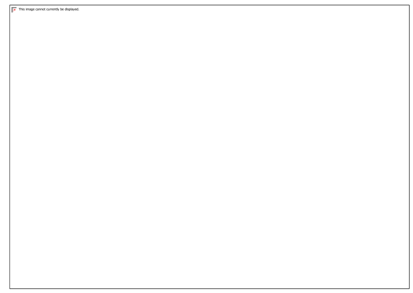
How do Tornadoes Form?



Before thunderstorms develop, a change in wind direction and an increase in wind speed with increasing height creates an invisible, horizontal spinning effect in the lower atmosphere.



Rising air within the thunderstorm updraft tilts the rotating air from horizontal to vertical.

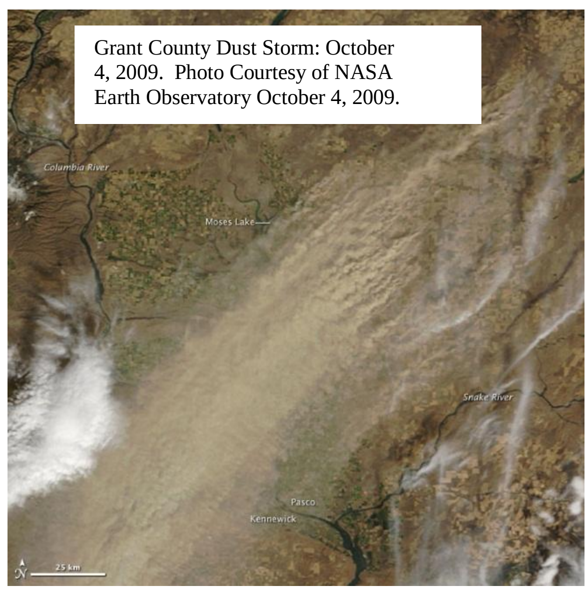


An area of rotation, 2-6 miles wide, now extends through much of the storm. Most strong and violent tornadoes form within this area of strong rotation.

- **Tornado** - A tornado is a violently rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 mph or more. Damage paths can be in excess of one mile wide and 50 miles longSome tornadoes may form during the early stages of rapidly developing thunderstorms, and may appear nearly transparent until dust and debris are picked up. Occasionally, two or more tornadoes may occur at the same time. Compared with other States, Washington ranks number 43 for frequency of Tornadoes, 29 for number of deaths, 27 for injuries and 46 for cost of damages.

Figure 15-3: Impacts of severe damaging winds (Source:Tetra Tech)

- **Straight-line winds**—Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts**—A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts**—A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts**—A small concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes, with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.
- **Gust front—**A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- **Derecho**—A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word “derecho” is of Spanish origin and means “straight ahead.” Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- **Bow Echo**—A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.
- **Dust Storms** – A **dust storm** is a meterological phenomenon common in arid and semi-arid regions. Dust storms arise when a gust front or other strong wind blows loose sand and dirt from a dry surface. Particles are transported by salation and suspension, causing soil to move from one place and deposit in another. Dryland farming is the primary cause of dust storms in Grant County, since dryland farmers rely on rainfall to water their crops, they engage in practices to maintain moisture in the soil. Such practices include leaving a field fallow for a year after harvesting to allow the buildup of water to build in the soil and covering the field with dry earth in an attempt to seal in the underlying.



Grant County Dust Storm: October 4, 2009. Photo Courtesy of NASA Earth Observatory October 4, 2009.

These practices make dryland agriculture susceptible to dust storms. These methods are used by farmers in Eastern Washington, which is an arid region. Of particular concern with respect to dust storms is the amount of volcanic ash which was deposited by the 1980 eruption of Mt. Saint Helens. The eruption deposited ash fall over 50% of Grant County. This ash ranges from sand like particles, to minute particles that can be carried away by slightest breeze. When mixed with sand layers from dryland farming, this has caused significant issues within the County.

15.1.3 Hail Storms

Hail occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice. Recent studies suggest that super-cooled water may accumulate on frozen particles near the back-side of a storm as they are pushed forward across and above the updraft by the prevailing winds near the top of the storm. Eventually, the hailstones encounter downdraft air and fall to the ground.

Hailstones grow two ways: by wet growth or dry growth. In wet growth, a tiny piece of ice is in an area where the air temperature is below freezing, but not super cold. When the tiny piece of ice collides with a super-cooled drop, the water does not freeze on the ice immediately. Instead, liquid water spreads across tumbling hailstones and slowly freezes. Since the process is slow, air bubbles can escape, resulting in a layer of clear ice. Dry growth hailstones grow when the air temperature is well below freezing and the water droplet freezes immediately as it collides with the ice particle. The air bubbles are “frozen” in place, leaving cloudy ice.

Hailstones can have layers like an onion if they travel up and down in an updraft, or they can have few or no layers if they are “balanced” in an updraft. One can tell how many times a hailstone traveled to the top of the storm by counting its layers. Hailstones can begin to melt and then re-freeze together, forming large and very irregularly shaped hail.

15.1.4 Severe Winter Storms

Grant County’s severe winter storms are an effect of two primary factors, the strength of the jet stream and the effect of the Cascade Mountains on orographic precipitation from the Pacific Ocean’s marine air masses and the flow of the continental air masses. The jet stream strengthens through the fall and reaches its maximum strength in winter, but the strength, position and orientation can vary each year. Some winters can be mild and relatively dry, while others may be cold, wet and laden with severe winter storms depending on the positioning of the jet stream as it guides the marine and continental air masses. Winter storm impacts can be lessened or exacerbated by El Nino or La Nina conditions in the Pacific Ocean. Southeastern Washington receives much of its precipitation during the winter and early spring and cold, wet, snowy winters are often the result in Eastern Washington during La Nina years. When the jet stream sags south of Washington State, cold, dry wintertime continental air masses from Canada and the Arctic can sometimes blanket the entire Columbia Basin region.

A cold wave is a weather phenomenon that is distinguished by a cooling of the air. Specifically, as used by the U.S. National Weather Service, a cold wave is a rapid fall in temperature within a 24 hour period requiring substantially increased protection to agriculture, industry, commerce, and social activities. The precise criterion for a cold wave is determined by the rate at which the temperature falls, and the minimum to which it falls. This minimum temperature is dependent on the geographical region and time of year. Cold waves generally are capable of occurring in any geological location and are formed by large cool air masses that accumulate over certain regions, caused by movements of air streams.

A cold wave can cause death and injury to livestock and wildlife. Exposure to cold mandates greater caloric intake for all animals, including humans, and if a cold wave is accompanied by heavy and persistent snow, grazing animals may be unable to reach necessary food and water, and die of hypothermia or starvation. Cold waves often necessitate the purchase of fodder for livestock at considerable cost to farmers. Human populations can be inflicted with frostbites when exposed for extended periods of time to cold and may result in the loss of limbs or damage to internal organs.

Cold waves that bring unexpected freezes and frosts during the growing season in mid-latitude zones can kill plants during the early and most vulnerable stages of growth. This results in crop failure as plants are killed before they can be harvested economically. Such cold waves have caused famines. Cold waves can also cause soil particles to harden and freeze, making it harder for plants and vegetation to grow within these areas.

As the County is largely agricultural, these factors are of significant concern in potential losses sustained due to extreme cold-weather events. Fires, paradoxically, become more hazardous during extreme cold. Water mains may break and water supplies may become unreliable, making firefighting more difficult. A cold front can also trigger heavy snowfall. Snowfall tends to form within regions of upward motion of air around a type of low-pressure system known as an extratropical cyclone. When extratropical cyclones deposit heavy, wet snow with a snow-water equivalent (SWE) ratio of between 6:1 and 12:1 and a weight in excess of 10 pounds per square foot (~50 kg/m2) piles onto trees or electricity lines, significant damage may occur on a scale usually associated with strong tropical cyclones. Large amounts of snow which accumulate on top of man-made structures can lead to structural failure. During snowmelt, acidic precipitation which previously fell in the snow pack is released and may harm aquatic life.

15.2. HAZARD PROFILE

15.2.1 Past Events

Table 15-1 summarizes severe weather events in Grant County since 1960, as recorded by the National Oceanic and Atmospheric Administration (NOAA).

The National Weather Service confirmed it was an EF-zero tornado which destroyed a barn in unincorporated Grant County near Moses Lake on May 19, 2010. Tornado like damage has been noted in the county in the past, but it is believed this is the first tornado confirmed by the National Weather Service. (Grant County Emergency Management 2010 Operations Records).

An October 4, 2009 dust storm caused visibility to drop to zero in parts of eastern Washington, as a large dust storm blew through. After numerous multi-vehicle accidents, sections of Interstate 90 near the town of Moses Lake and several local roads were closed for several hours. Grant County Emergency Management initiated the development of a joint Emergency Alert System message with neighboring Adams County to ask citizens not to travel. The storm reached gusts of 45mph. Approximately 25 vehicle accidents were reported in direct relation to the dust storm, some injuries were sustained. (Grant County Emergency management 2009 Operations records).

Presidential Disaster Declation #1682 included a severe winter wind storm that spread across the State of Washington in December14 and 15 of 2006. Damages were incurred in Grant County including downed power lines, toppled trees, rooftops torn from rafters and trusses, power outages lasting up to a week in the Quincy area, damaged irrigation circles and road closures. There were damages at a local road district shop (lighting, fencing, signs) The National Weather Service had automated weather recording systems, however, none of these locations were in the most damaged areas. Wind gusts were recorded by these systems at 72 miles per hour, and a private resident recorded wind at 135 miles per hour. Reported losses were $865,100 for residential/commercial and $2,334,924 for government; totaling estimated loss at $3,200,024.

An additional severe winter wind storm impacted Grant County on January 7, 2007 that produced similar damage. Reported losses were $308,000 for residential/commercial and $2,004,000 for government; totaling estimated loss at 2,312,000.

15.2.2 Location

Severe weather events have the potential to happen anywhere in the planning area. Communities in low-lying areas next to streams or lakes are more susceptible to flooding. Wind events are most damaging to areas that are heavily wooded. The maps at the end of this chapter show weather conditions over Grant County.

15.2.3 Frequency

The severe weather events for Grant County shown in Table 15-1 are often related to high winds associated with winter storms and thunderstorms, as well as Tornadoes and Dust Storms. The planning area can expect to experience exposure to some type of severe weather event at least annually.

TABLE 15-1.
SEVERE WINTER STORM EVENTS IMPACTING PLANNING AREA SINCE 1960

Date	Type	Deaths or Injuries	Property Damage
April 5, 1972	Tornado (F2)	0	$25,000 (1972 values)
July 1, 1979	Tornado (F0)	0	Unknown
8/10/1985	Tornado (F1)	0	Unknown
5/11/2003	Tornado (F0)	0	Unknown
5/19/2010	Tornado (F0)	0	$2,000
10/18/1991	Dust Storm	0	Unknown
11/3/1993	Dust Storm	1 injured	Unknown
7/24/1994	Dust Storm	1 death/14 injured	Unknown
October 4, 2009	Dust Storm	0	Unknown
6/28/1968	Hail	0	Unknown
9/17/1985	Hail	0	Unknown
5/31/1997	Tstm/Hail	0	$15,000
7/10/1998	Hail	0	Unknown
7/21/1999	Tstm/Hail	0	$15,000
6/27/2001	Hail	0	Unknown
4/30/2003	Hail	0	Unknown

**TABLE 15-1.
SEVERE WINTER STORM EVENTS IMPACTING PLANNING AREA SINCE 1960**

Date	Type	Deaths or Injuries	Property Damage
5/20/2004	Hail	0	Unknown
5/4/2005	Hail	0	$50,000
7/1/2008	Hail	0	Unknown
6/12/2009	Hail	0	Unknown
6/23/2010	Hail	0	$50,000
7/14/1966	Tstm Wind	0	Unknown
6/9/1969	Tstm Wind	0	Unknown
8/9/1982	Tstm Wind	0	Unknown
5/12/1988	Tstm Wind	0	Unknown
5/31/1997	Tstm Wind	0	$215,000
07/0/1998	Tstm Wind	0	$15,000
7/21/1999	Tstm Wind/Hail	0	$15,000
6/27/2001	Tstm Wind	0	Unknown
10/17/2004	Tstm Wind	0	$30,000
4/23/2005	Tstm Wind	0	Unknown
5/18/2006	Tstm Wind	0	Unknown
07/12/2006	Tstm Wind	0	Unknown
07/01/2008	Tstm Wind	0	Unknown
6/4/2009	Tstm Wind	0	$2,000
5/19/2010	Tstm Wind	0	$1,000
11/3/1993	Severe Wind	0	Unknown
08/06/1999	Lightning	0	Unknown
8/21/1999	Lightning	0	Unknown
7/7/2002	Lightning	0	Unknown
5/18/2006	Lightning	0	Unknown
1967	Heatwave	0	Unknown
Dec. 1996-Feb. 1997 Disaster Declaration: 1159	Ice, Wind, Snow, Landslide and Flooding	0	Unknown
12/14-12/ 15/2006 Disaster Declaration: 1682	Severe Winter Storm, Wild, Landslide and Mudslides	0	$3,200,000
2/7/2007	Severe Winter Storm	0	$2,312,000

15.2.4 Severity

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon, but can occur. Roads may become impassable due to flooding, downed trees, ice or snow, or a landslide, or visibility can become an issue, such as during a dust storm. Power lines may be downed due to high winds or ice accumulation, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury. High winds associated with thunderstorms have caused significant damage within the County as evidenced in Table 15.1.

Windstorms can be a frequent problem in the planning area and have been known to cause damage to utilities. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30 percent higher.

Within the planning area, dust storms caused by dryland farming are also a significant concern, and, as in the 1994 dust storm, has a high potential for life safety.

Tornadoes are potentially the most dangerous of local storms, but they are not common in the planning area. If a major tornado were to strike within the populated areas of the county, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings may be damaged or destroyed.

15.2.5 Warning Time

Meteorologists can often predict the likelihood of a severe storm. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

15.3. SECONDARY HAZARDS

The most significant secondary hazards associated with severe local storms are floods, falling and downed trees, landslides and downed power lines. Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails.

15.4. CLIMATE CHANGE IMPACTS

Climate change presents a significant challenge for risk management associated with severe weather. The frequency of severe weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate (see Figure 15-2). The changing hydrograph caused by climate change could have a significant impact on the intensity, duration and frequency of storm events. All of these impacts could have significant economic consequences.

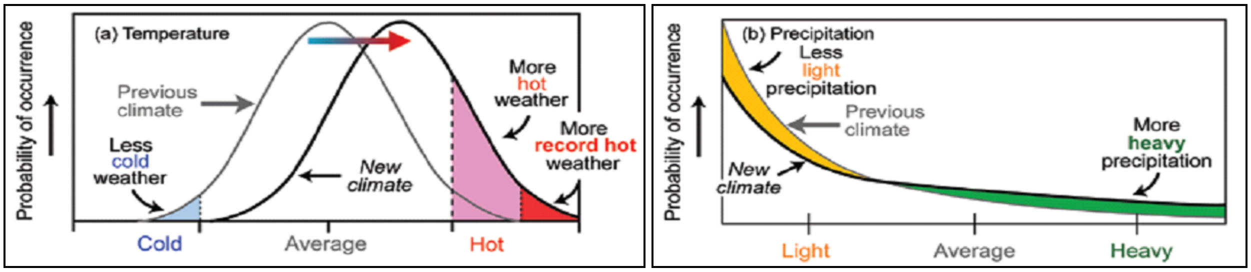


Figure 15-2. Severe Weather Probabilities in Warmer Climates

15.5. EXPOSURE

15.5.1 Population

A lack of data separating severe weather damage from flooding and landslide damage prevented a detailed analysis for exposure and vulnerability. However, it can be assumed that the entire planning area is exposed to some extent to severe weather events. Certain areas are more exposed due to geographic location and local weather patterns. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out, while populations in low-lying areas are at risk for possible flooding.

15.5.2 Property

According to the Grant County Assessor, there are 36,576 buildings within the census tracts that define the planning area. Most of these buildings are residential. It is estimated that 30 percent of the residential structures were built without the influence of a structure building code with provisions for wind loads. All of these buildings are considered to be exposed to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations (located on hilltops or exposed open areas) may risk the most damage. The frequency and degree of damage will depend on specific locations.

15.5.3 Critical Facilities and Infrastructure

All critical facilities exposed to flooding (Chapter 13) are also likely exposed to severe weather. Additional facilities on higher ground may also be exposed to wind damage or damage from falling trees. The most common problems associated with severe weather are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated. Phone, water and sewer systems may not function. Roads may become impassable due to ice or snow or from secondary hazards such as landslides.

15.5.4 Environment

The environment is highly exposed to severe weather events. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat. Storm surges can erode beachfront bluffs and redistribute sediment loads.

15.6. VULNERABILITY

15.6.1 Population

Vulnerable populations are the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe weather events and could suffer more secondary effects of the hazard.

15.6.2 Property

All property is vulnerable during severe weather events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Those in higher elevations and on ridges may be more prone to wind damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse.

Loss estimations for the severe weather hazard are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 15-2 lists the loss estimates to the general building stock.

Table 15-2.

Buildings Vulnerable to Severe Weather Hazard

City	Assessed Value	10% Damage	30% Damage	50% Damage
Coulee City	$34,983,000	$3,498,300	$10,494,900	$17,491,500
Electric City	$82,763,000	$8,276,300	$24,828,900	$41,381,500
Ephrata	$591,108,000	$59,110,800	$177,332,400	$295,554,000
George	$22,363,000	$2,236,300	$6,708,900	$11,181,500
Grand Coulee	$76,731,000	$7,673,100	$23,019,300	$38,365,500
Hartline	$11,020,000	$1,102,000	$3,306,000	$5,510,000
Krupp	$5,395,000	$539,500	$1,618,500	$2,697,500
Mattawa	$86,170,000	$8,617,000	$25,851,000	$43,085,000
Moses Lake	$1,582,546,000	$158,254,600	$474,763,800	$791,273,000
Quincy	$405,231,000	$40,523,100	$121,569,300	$202,615,500
Royal City	$56,591,000	$5,659,100	$16,977,300	$28,295,500
Soap Lake	$109,303,000	$10,930,300	$32,790,900	$54,651,500
Warden	$107,485,000	$10,748,500	$32,245,500	$53,742,500
Wilson Creek	$16,492,000	$1,649,200	$4,947,600	$8,246,000
Unincorporated	$4,424,408,000	$442,440,800	$1,327,322,400	$2,212,204,000
Total	**$7,612,589,000**	**$761,258,900**	**$2,283,776,700**	**$3,806,294,500**

15.6.3 Critical Facilities and Infrastructure

Incapacity and loss of roads are the primary transportation failures resulting from severe weather, mostly associated with secondary hazards. Landslides caused by heavy prolonged rains can block roads are. High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Snowstorms in higher elevations can significantly impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly.

Prolonged obstruction of major routes due to landslides, snow, debris or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts for an entire region.

Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting electricity and communication. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

15.6.4 Environment

The vulnerability of the environment to severe weather is the same as the exposure.

15.7. FUTURE TRENDS IN DEVELOPMENT

All future development will be affected by severe storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The planning partners have adopted the International Building Code in response to Washington mandates. This code is equipped to deal with the impacts of severe weather events. Land use policies identified in general plans within the planning area also address many of the secondary impacts (flood and landslide) of the severe weather hazard. With these tools, the planning partnership is well equipped to deal with future growth and the associated impacts of severe weather. Additional past experience has demonstrated the need for increased payload capacity for roof structures, and the County has undertaken steps to increase the capacity for snow loads within their Building Code requirements.

15.8. SCENARIO

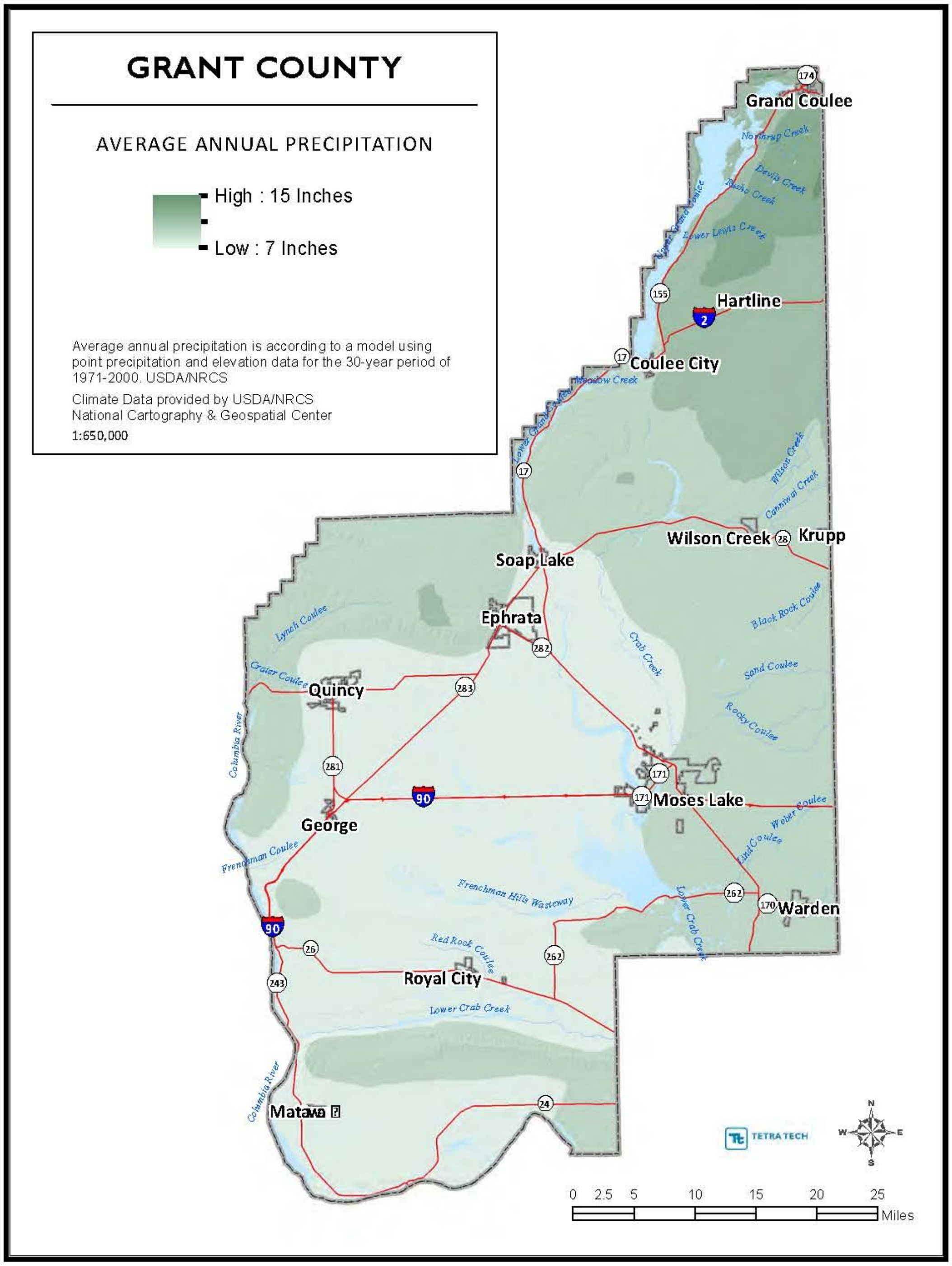
Although severe local storms are infrequent, impacts can be significant, particularly when secondary hazards of flood and landslide occur. A worst-case event would involve prolonged high winds during a winter storm accompanied by thunderstorms. Such an event would have both short-term and longer-term effects. Initially, schools and roads would be closed due to power outages caused by high winds and downed tree obstructions. In more rural areas, some subdivisions could experience limited ingress and egress. Prolonged rain could produce flooding, overtopped culverts with ponded water on roads, and landslides on steep slopes. Flooding and landslides could further obstruct roads and bridges, further isolating residents.

15.9. ISSUES

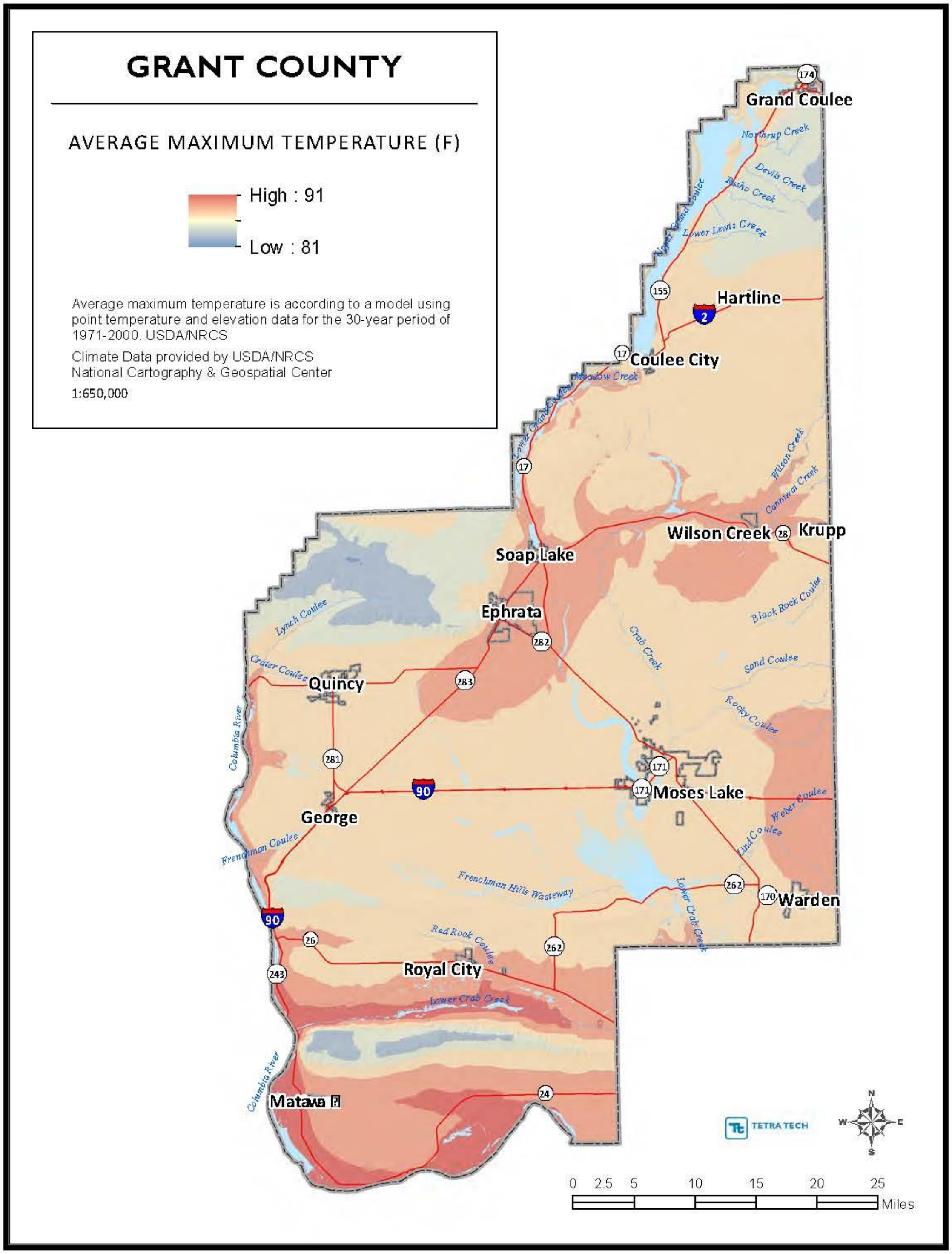
Important issues associated with a severe weather in the Grant County planning area include the following:

- Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to severe weather events such as windstorms or a severe weather invent which includes high snow accumulations because of the load factor on roofs.

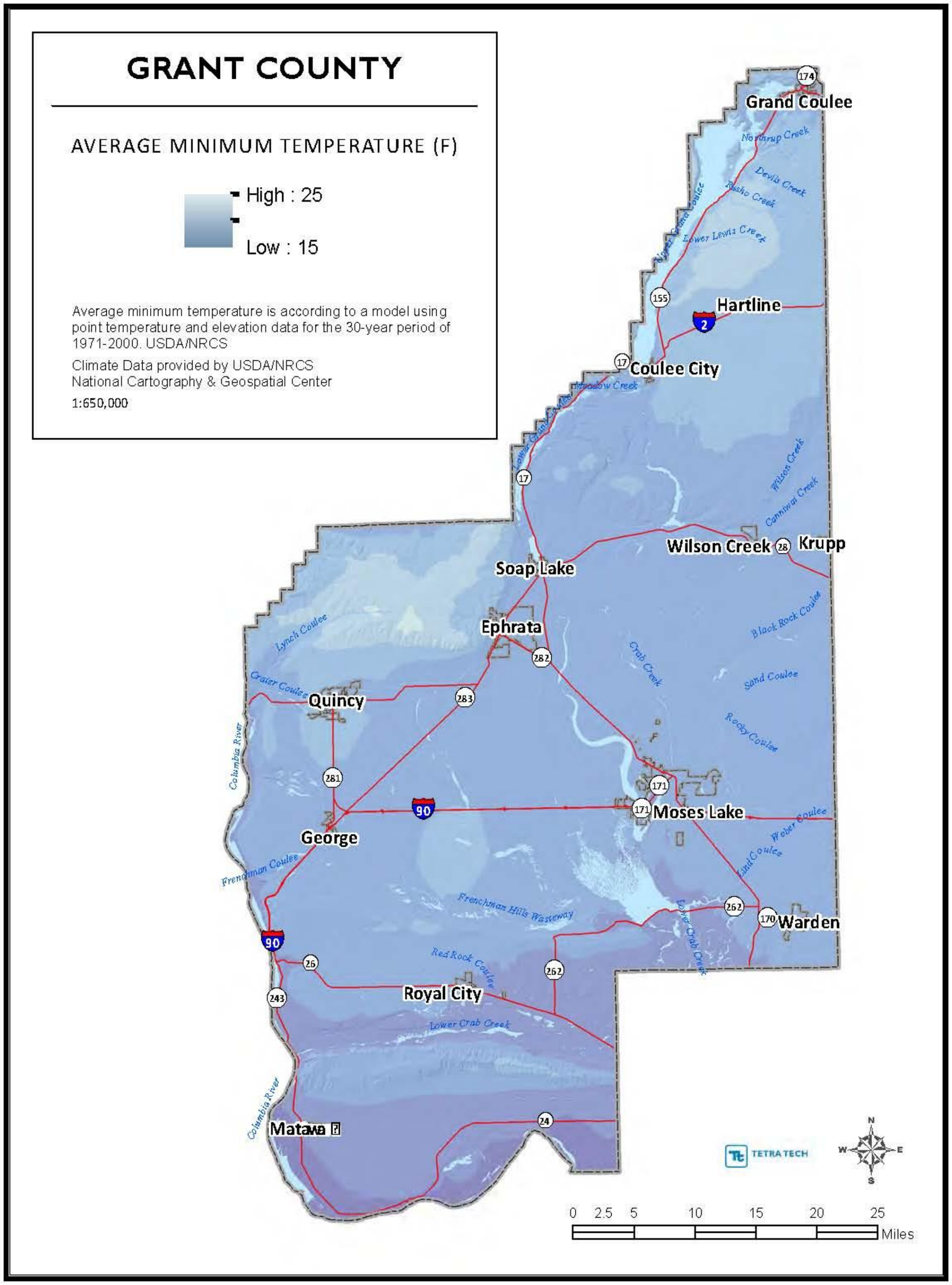
- Redundancy of power supply must be evaluated.
- The capacity for backup power generation is limited.
- Isolated population centers.
- Increased susceptibility of agriculture and livestock to extreme cold weather can have a substantial economic impact.



Map 16-1 Grant County Average Annual Precipitation



Map 16-2 Grant County Average Maximum Temperature



Map 16-3 Grant County Average Minimum Temperature

CHAPTER 16.
VOLCANO

16.1. GENERAL BACKGROUND

Hazards related to volcanic eruptions are distinguished by the different ways in which volcanic materials and other debris are emitted from the volcano. The molten rock that erupts from a volcano (lava) forms a hill or mountain around the vent. The lava may flow out as a viscous liquid, or it may explode from the vent as solid or liquid particles. Ash and fragmented rock material can become airborne and travel far from the erupting volcano to affect distant areas.

DEFINITIONS

Lahar—A rapidly flowing mixture of water and rock debris that originates from a volcano. While lahars are most commonly associated with eruptions, heavy rains, and debris accumulation, earthquakes may also trigger them.

Lava Flow—The least hazardous threat posed by volcanoes. Cascades volcanoes are normally associated with slow moving andesite or dacite lava.

Stratovolcano—Typically steep-sided, symmetrical cones of large dimension built of alternating layers of lava flows, volcanic ash, cinders, blocks, and bombs, rising as much as 8,000 feet above their bases. The volcanoes in the Cascade Range are all stratovolcanoes.

Tephra—Ash and fragmented rock material ejected by a volcanic explosion

Volcano—A vent in the planetary crust from which magma (molten or hot rock) and gas from the earth's core erupts.

16.2. HAZARD PROFILE

16.2.1 Past Events

Figure 16-1 and Table 16-1 summarize past eruptions in the Cascades. In the 1980 Mount St. Helens eruption, 23 square miles of volcanic material buried the North Fork of the Toutle River and there were 57 human fatalities.

While Grant County has no active volcanoes within its boundaries, when the May 1980 eruption of Mt. St. Helens occurred, the explosive event deposited ash fall over 50% of Grant County. That ash ranged from sand like particles to minute particles that at present date can still be whisked away by slightest breeze. This has increased the issue with wind and dust storms within the County.

16.2.2 Location

Figure 16-1 shows the location of the Cascade Range volcanoes, most of which have the potential to produce a significant eruption. The Cascade Range extends more than 1,000 miles from southern British Columbia into northern California and includes 13 potentially active volcanic peaks in the U.S. Figure 16-2 shows probabilities of ***tephra*** accumulation from Cascade volcanoes in the Pacific Northwest (tephra is fragmented rock material ejected by a volcanic explosion).

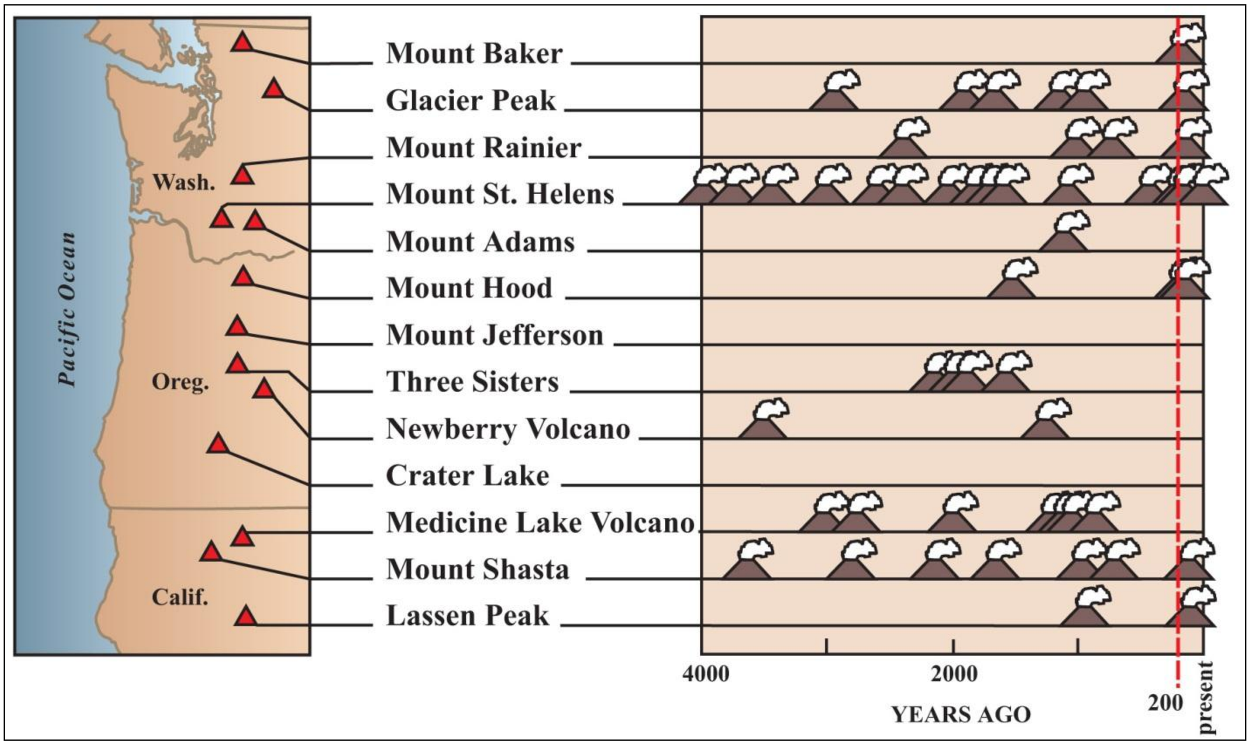


Figure 16-1. Past Eruptions in the Cascade Range

TABLE 16-1.
PAST ERUPTIONS IN WASHINGTON

Volcano	Number of Eruptions	Type of Eruptions
Mount Adams	3 in the last 10,000 years, most recent between 1,000 and 2,000 years ago	Andesite lava
Mount Baker	5 eruptions in past 10,000 years; mudflows have been more common (8 in same time period)	Pyroclastic flows, mudflows, ash fall in 1843.
Glacier Peak	8 eruptions in last 13,000 years	Pyroclastic flows and lahars
Mount Rainier	14 eruptions in last 9000 years; also 4 large mudflows	Pyroclastic flows and lahars
Mount St Helens	19 eruptions in last 13,000 years	Pyroclastic flows, mudflows, lava, and ash fall

Grant County lays down-wind from Mt. St. Helens, Mt Hood, and Mt. Adams. The County could also be inflicted with results from a volcanic eruption from Mt. Rainier, Mt. Baker, and Glacier Peak.

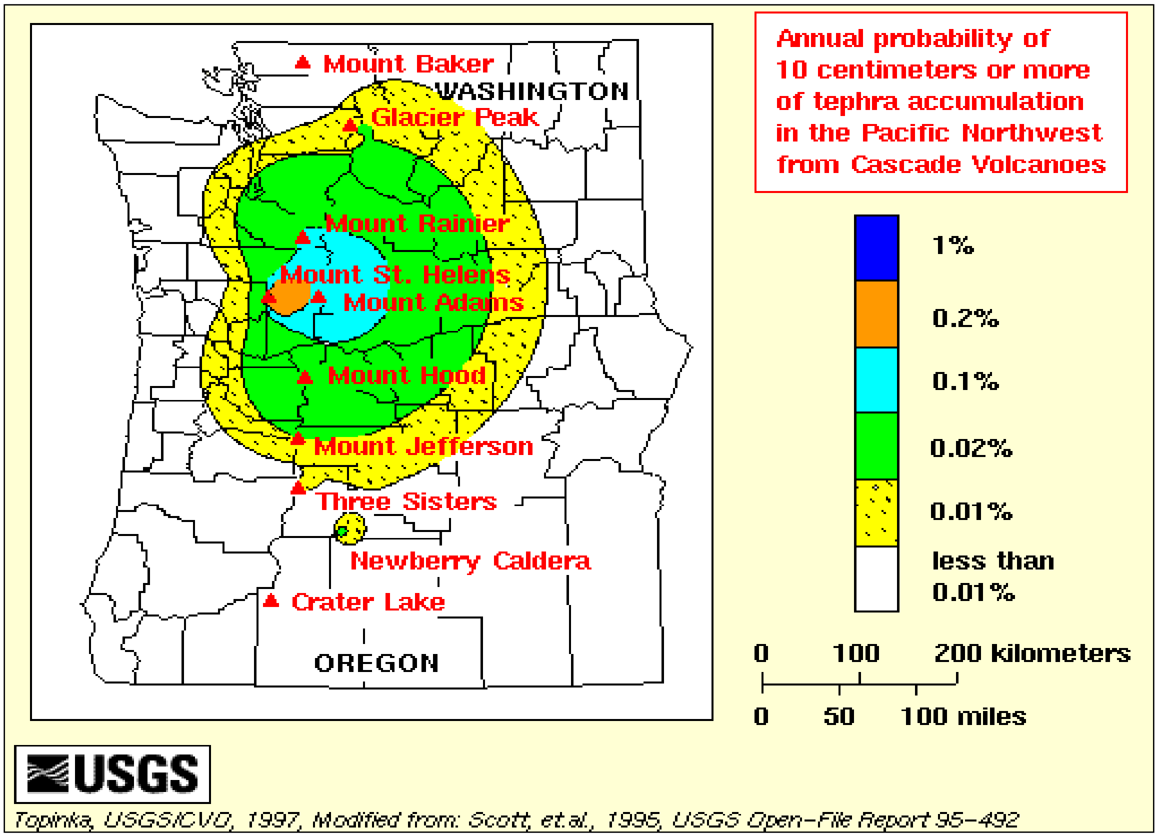


Figure 16-2. Probability of Tephra Accumulation in Pacific Northwest

16.2.3 Frequency

Many Cascade volcanoes have erupted in the recent past and will be active again in the foreseeable future. Given an average rate of one or two eruptions per century during the past 12,000 years, these disasters are not part of our everyday experience; however, in the past hundred years, California's Lassen Peak and Washington's Mount St. Helens have erupted with terrifying results. The U.S. Geological Survey classifies Glacier Peak, Mt. Adams, Mt. Baker, Mt. Hood, Mt. St. Helens, and Mt. Rainier as potentially active volcanoes in Washington State. Mt. St. Helens is by far the most active volcano in the Cascades, with four major explosive eruptions in the last 515 years. Figure 16-2 shows the annual probability of a tephra, or ash, accumulation of 10 centimeters or more (about 4 inches). The probably of ash accumulations of 10 centimeters or more within Grant County ranges from 0.02-0.01 percent in any given year.

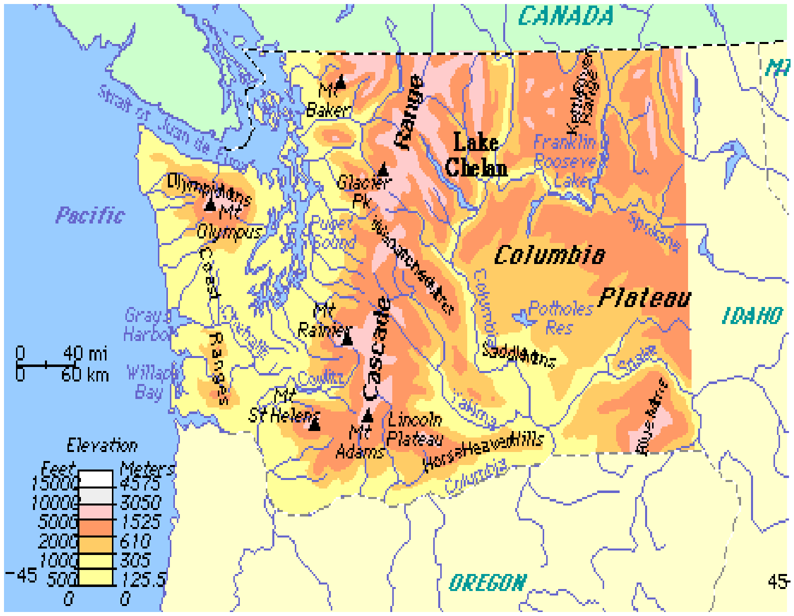


Figure 16-3. Cascade Mountains and Volcanoes

16.2.4 Severity

The explosive disintegration of Mount St. Helens' north flank in 1980 vividly demonstrated the power that Cascade volcanoes can unleash. A 1-inch deep layer of ash weighs an average of 10 pounds per square foot, causing danger of structural collapse. Ash is harsh, acidic and gritty, and it has a sulfuric odor. Ash may also carry a high static charge for up to two days after being ejected from a volcano. When an ash cloud combines with rain, sulfur dioxide in the cloud combines with the rain water to form diluted sulfuric acid that may cause minor, but painful burns to the skin, eyes, nose, and throat.

16.2.5 Warning Time

Constant monitoring of all active volcanoes means that there will be more than adequate time for evacuation before an event. Since 1980, Mount St. Helens has settled into a pattern of intermittent, moderate and generally non-explosive activity, and the severity of tephra, explosions, and lava flows have diminished. All episodes, except for one very small event in 1984, have been successfully predicted several days to three weeks in advance. However, scientists remain uncertain as to whether the volcano's current cycle of explosivity ended with the 1980 explosion. The possibility of further large-scale events continues for the foreseeable future.

16.3. SECONDARY HAZARDS

The secondary hazards associated with volcanic eruptions are customarily mud flows and landslides, as well as traffic disruptions and increased issues with respect to dust storms recirculating the ash.

16.4. CLIMATE CHANGE IMPACTS

Large-scale volcanic eruptions can reduce the amount of solar radiation reaching the Earth's surface, lowering temperatures in the lower atmosphere and changing atmospheric circulation patterns. The massive outpouring of gases and ash can influence climate patterns for years. Sulfuric gases convert to sub-micron droplets containing about 75 percent sulfuric acid. These particles can linger three to four years in the stratosphere. Volcanic clouds absorb terrestrial radiation and scatter a significant amount of incoming solar radiation, an effect that can last from two to three years following a volcanic eruption.

16.5. EXPOSURE AND VULNERABILITY

Grant County lays down-wind from Mt. St. Helen's, Mt Hood, and Mt. Adams. The County could also be inflicted with results from a volcanic eruption from Mt. Rainier, Mt. Baker, and Glacier Peak. Ash fallout from the explosive events of volcano's can inflict upon the county as much devastations as a severe winter storm. Transportation, utilities and communication can be interrupted and masses of people stranded. The clean-up from ash fall will inflict enormous economic loss. Additionally, because of the County's dryland farming, the ash continues to be an issue years later, as is the case with Mt. Saint Helens ash which still produces dust storms in the County.

16.5.1 Population

The whole population of Grant County is exposed to the effects of a tephra fall. The populations most vulnerable to the effects of a tephra fall are the elderly, the very young and those already experiencing ear, nose and throat problems. Homeless people, who may lack adequate shelter, are also vulnerable to the effects of a tephra fall, although Grant County has a small population of homeless people who would not be able to find adequate shelter or assistance during an event. Of significant concern is the issue with dust storms, and the recirculating of the ash during such times, causing health concerns and concerns for crops, which would have an economic impact upon the population.

16.5.2 Property

All of the property and infrastructure exposed to nature in the County are exposed to the effects of a tephra fall. Vulnerable property includes equipment and machinery left out in the open, such as combines, whose parts can become clogged by the fine dust. Additionally, roofs may not be built to withstand the weight of ash, especially when mixed with rain or snow, which would increase its weight. This could potentially impact both public and private structures. Infrastructure, such as drainage systems, are also potentially vulnerable to the effects of a tephra fall, since the fine ash can clog pipes and culverts. This may be more of a problem if an eruption occurs during winter or early spring when precipitation is highest and floods are most likely. To estimate the loss potential for this hazard, a qualitative approach was used, based on recommendations from the FEMA State and Local Mitigation Planning How-to Guides. Loss estimation tools such as HAZUS-MH currently do not have the ability to analyze impacts from volcano hazards.

16.5.3 Environment

The environment is highly exposed to the effects of a volcanic eruption. Even if the related ash fall from a volcanic eruption were to fall elsewhere, it could still be spread throughout the County by the surrounding rivers and streams. A volcanic blast would expose the local environment to many effects such as lower air quality, and many other elements that could harm local vegetation and water quality.

16.6. FUTURE TRENDS IN DEVELOPMENT

All future development has the potential of being impacted by ash fall generated from volcanic events. The weight of the ash should be taken into consideration when new construction occurs to insure reduced impact from damaging events by strengthening the load values of roofs.

16.7. SCENARIO

In the event of a volcanic eruption in Grant County, while there would probably not be any loss of life due to adequate warnings, the potential does exist due to the relatively large amounts of ash fall which occurred during the eruption of Mt. Saint Helens. The elder, young and individuals with breathing problems would be at greater risk of impact. There would also be loss of use property and crops due to ash and sulfuric acid developing when the ash mixes with rain or snow. The economic impact from ash fall and the continuing issue of ash becoming airborne as a result of dust storms would continue for years into the future. People and animals without shelter would be affected, as would farm equipment which was left out in the open.

16.8. ISSUES

Since volcanic episodes have been fairly predictable in the recent past, there is probably not much concern about loss of life, but there is concern about loss of property and infrastructure and severe environmental impacts.

CHAPTER 17.
WILDFIRE

17.1. GENERAL BACKGROUND

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use, and arson.

Fire hazards present a considerable risk to vegetation and wildlife habitats. Short-term loss caused by a wildfire can include the destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, and destruction of cultural and economic resources and community infrastructure. Vulnerability to flooding increases due to the destruction of watersheds. The potential for significant damage to life and property exists in areas designated as “wildland urban interface (WUI) areas,” where development is adjacent to densely vegetated areas.

17.2. HAZARD PROFILE

17.2.1 Past Events

Grant County has a rich fire history. The 2000 fire season was the worst since the Chelan fires in 1994. The Governor signed a proclamation early in the season because of the Northwest was experiencing a disastrous fire season. The proclamation authorized firefighting training for the National Guard in the event federal, state and local firefighting resources would be unable to handle the fires.

In 1996 Grant County required a state mobilization for the Baird Springs fire. Other major wild land fires that have needed outside assistance are: 1998 Lower Crab Creek, 1999 Sheep Canyon, 1998 Wahitis Peak, and the 1999 Baird Springs fire. More recent state mobilization fires within Grant County include: 2006 Rocky Ford, 2007 Seep Lakes, 2008 Willows Creek, 2009 Grant County Complex, 2012 Barker Canyon (Grant County Department of Emergency Management 2013).

None of the planning partners within Grant County are designated by the 2010 Washington State Hazard Mitigation Plan as being an Urban Interface Community at high risk to wildfire danger. There are also no Firewise Communities within Grant County.

DEFINITIONS

Conflagration—A fire that grows beyond its original source area to engulf adjoining regions. Wind, extremely dry or hazardous weather conditions, excessive fuel buildup and explosions are usually the elements behind a wildfire conflagration.

Firestorm—A fire that expands to cover a large area, often more than a square mile. A firestorm usually occurs when many individual fires grow together into one. The involved area becomes so hot that all combustible materials ignite, even if they are not exposed to direct flame. Temperatures may exceed 1000°C. Superheated air and hot gases of combustion rise over the fire zone, drawing surface winds in from all sides, often at velocities approaching 50 miles per hour. Although firestorms seldom spread because of the inward direction of the winds, once started there is no known way of stopping them. Within the area of the fire, lethal concentrations of carbon monoxide are present; combined with the intense heat, this poses a serious life threat to responding fire forces. In very large events, the rising column of heated air and combustion gases carries enough soot and particulate matter into the upper atmosphere to cause cloud nucleation, creating a locally intense thunderstorm and the hazard of lightning strikes.

Interface Area—An area susceptible to wildfires and where wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

Wildfire—Fires that result in uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and can cause a great deal of destruction.

17.2.2 Location

A wildfire or major brush fire could occur anywhere within Grant County. Likewise, because of the significant amount agricultural lands, and the dryland farming practiced within the county, fires could easily spread. The County also participates in the Conservation Reserve Program, where large areas of cultivated land are fallow. The purpose of this program is to pay farmers to not cultivate lands which are highly erodable, and thus maintain the usable life of the soil. Wildfires can also occur on lands that are used as pasture or open range. As there is limited perception that falls, all of these factors could have significant impact on the County and its jurisdictions. The Washington State Enhanced Hazard Mitigation Plan does not reference Grant County as a high wildfire risk area. Map 17-1 illustrates the fire regime areas for Grant County.

17.2.3 Frequency

Wildland fires responded to by city and county departments are largely started by human causes. Some of human causes for wild land fires may include: cigarettes, fireworks, and outdoor burning. Passing trains are known to cause sparks that can trigger wildfires. Wild land fires started by heat spark ember or flames caused the largest dollar loss, followed by debris burning and cigarettes. Loss per incident is three times higher than any other fire cause.

Of concern within Grant County are the hazardous materials stored countywide. Pesticides and fertilizers used in the agricultural industry can cause significant hazards should a location storing such materials burn.

In an effort to combat fires, Grant County participates in the Mid-Columbia Region Fire Plan, which includes Adams, Chelan, Douglas, Grant and Okanogan Counties. The purpose is to pool resources to assist the county and its surrounding jurisdictions in fighting fires throughout the designated region.

Grant County has been fortunate in that it has not experienced any large-scale fires which have caused death, injury and loss to community infrastructure, businesses and homes. Grant County typically has wild land fires annually including the burning of great abundances of dry vegetation. During wet winters and springs, the growth of wild vegetation greatly enhances wild land fire risks when the vegetation dries out. Many wild land fires which have occurred destroyed thousands of acres of land. Some of these fires have involved crops of wheat, barley and field corn.

Grant County has a Fire Mobilization Plan, which has been activated several times in an effort to gain control of fires. The major fires to impact the County are as follows:

State Fire Mobilization was necessary for the Barker Canyon Complex wild land fire in September 2012, which included the Leahy Junction Fire in Grant and Douglas Counties. Approximately 90,000 acres were involved. A local Proclamation of Emergency was declared by the Board of County Commissioners in Grant County. Additionally, the Governor declared a State of Emergency for all counties east of the Cascade Mountains to deploy additional state resources.

In September of 2010, a fire burned northwest of Quincy, requiring air support from the Department of Natural Resources and approximately 40 apparatus from Grant, Chelan, and

Douglas Counties. The Emergency Operations Center at Grant County Emergency Management was activated in a supportive effort.
(Grant County Emergency Management State Issued Mission Number Archives (Mission # 10-2957 and # 12-3389) Emergency Proclamation Record September 10, 2012 and WA State Emergency Management Emergency Operations Center Sit-Rep)

On August 21, 2009 the Grant County Board of Commissioners signed a local Declaration of Emergency for the Grant County Complex Fire, which went to State Mobilization level to include 10 wildland strike teams, 4 20-person hand crews and a helicopter to support local firefighting resources. The complex fire included 3 separate fires that threatened 40 homes.

Other recent State Fire Mobilization Activations in Grant County include the 2008 Willows Creek fire, in 2007 the Seep Lakes, Black Rock, and Beasley Hill fires, and in 2006 the Rocky Ford fire. (Washington State Fire Mobilization History of Activations http://www.wsp.wa.gov/fire/docs/mobilization/mobe_history_for_2008.pdf)

As indicated, the 2000 fire season was the worst since the Chelan fires in 1994, with additional fires within the County occurring in 1998 (2), and 1999 (2). Other major wild land fires that have needed outside assistance are: 1998 Lower Crab Creek, 1999 Sheep Canyon, 1998 Wahitis Peak, and the 1999 Baird Springs fire.

August 2-3, 1996 Baird Springs Fire: This wild land fire spread over 14,000 acres and required the declaration of State Fire Resource Mobilization assistance. The fire required aerial fire-fighting strategy including four United States Forest Service aircraft and two Department of Natural Resources helicopters.

July 14, 1987 Sun Lakes State Park Fire: This wild land fire consumed 24,000 acres within a 38 square mile area threatening the Town of Coulee City. Grant County Fire Protection District #7 and Coulee City Fire Department requested mutual aid from seven neighboring jurisdictions to fight the flames driven by 20 m.p.h. wind gusts. The estimated loss in equipment owned by the fire departments, fencing, grazing lands and personnel costs totaled $296,500.00.

Small, minor brush fires can be expected at least every year, especially during the dry hot summer months. Many of these are caused by human carelessness, such as from fireworks or cigarettes tossed from vehicles.

17.2.4 Severity

Risk to communities is generally determined by the number, size and types of wildfires that have historically affected the area; topography; fuel and weather; suppression capability of local and regional resources; where and what types of structures are in the WUI and; what types of pre-fire mitigation activities have been completed. Identifying areas most at risk to fire or to determine the course a fire takes requires precise science. It is not the intent of this plan to make those assumptions. Datasets necessary to conduct that type of analysis are limited for the County.

Potential losses from wildfire include human life, structures and other improvements, and natural resources. Within Grant County the vast majority of the land area is used for agricultural purposes. All of these areas are vulnerable to wild land or wild land-urban interface fires. Most of the land areas of Grant County receive about 8-10 inches of rainfall annually. This dry climate and the frequent occurrence of strong, dry winds can cause natural fire fuels to reach a combustible state.

Additionally, high summer temperatures coupled with seasonal low rainfall amounts sometimes lead to summer drought conditions in the agricultural industry, which occur frequently within the County. While there has been a lack of ignition during times of serious fire danger in Grant County, the absence of large fires coupled with reduced burning has also resulted in greater fuel loading which could lead to a catastrophic fire given the right set of conditions with respect to natural fire regimes.

Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

Irrigated farmlands, improved fire spotting techniques, better equipment, and trained personnel are major factors in the fairly small number of wildland fires that have occurred in the county.

17.2.5 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. Since fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest. Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm.

If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. A fire’s peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

17.3. SECONDARY HAZARDS

Wildfires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildfires cause the contamination of reservoirs, destroy transmission lines and contribute to flooding. They strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildfire. Most wildfires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

In addition, the following secondary effects are possible; rehabilitation efforts after a fire occurs can reduce but cannot eliminate them:

Damaged Fisheries—Critical trout fisheries throughout the west and salmon and steelhead fisheries in the Pacific Northwest can suffer from increased water temperatures, sedimentation, and changes in water quality and chemistry.

• Flooding—Most wildland fires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This results in an increase in runoff generated by storm events, thus increasing the chance of flooding.

• Soil Erosion—Fires remove the protective covering provided by foliage and dead organic matter, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.

• Spread of Invasive Plant Species—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes and become difficult and costly to control.

• Disease and Insect Infestations—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.

• Destroyed Endangered Species Habitat—Catastrophic fires can have devastating consequences for endangered species. For instance, the Biscuit Fire in Oregon destroyed 125,000 to 150,000 acres of spotted owl habitat.

• Soil Sterilization—Topsoil exposed to extreme heat can become water repellent, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

17.4. CLIMATE CHANGE IMPACTS

Fire in western ecosystems is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Historically, drought patterns in the West are related to large-scale climate patterns in the Pacific and Atlantic oceans. The El Niño–Southern Oscillation in the Pacific varies on a 5- to 7-year cycle, the Pacific Decadal Oscillation varies on a 20- to 30-year cycle, and the Atlantic Multidecadal Oscillation varies on a 65- to 80-year cycle. As these large-scale ocean climate patterns vary in relation to each other, drought conditions in the U.S. shift from region to region. El Niño years bring drier conditions to the Pacific Northwest and more fires.

Climate scenarios project summer temperature increases between 2ºC and 5°C and precipitation decreases of up to 15 percent. Such conditions would exacerbate summer drought and further promote high-elevation wildfires, releasing stores of carbon and further contributing to the buildup of greenhouse gases. Forest response to increased atmospheric carbon dioxide—the so-called “fertilization effect”—could also contribute to more tree growth and thus more fuel for fires, but the effects of carbon dioxide on mature forests are still largely unknown. High carbon dioxide levels should enhance tree recovery after fire and young forest regrowth, as long as sufficient nutrients and soil moisture are available, although the latter is in question for many parts of the western United States because of climate change.

17.5. EXPOSURE

17.5.1 Population

Population was estimated using the structure count of buildings in the Regime area and applying the census value of 3 persons per household for Grant County. These estimates are shown in Table 17-1.

Table 17-1.
Population Estimates Within Fire Regime Zones

	Regime I		Regime III		Regime IV	
	Buildings	Population	Buildings	Population	Buildings	Population
Coulee City	0	0	16	45	333	762
Electric City	0	0	14	33	541	1206
Ephrata	73	186	2520	6,666	126	336
George	104	234	53	132	0	0
Grand Coulee	2	0	1	3	611	1254
Hartline	0	0	5	15	117	219
Krupp	0	0	30	51	13	21
Mattawa	456	1143	0	0	0	0
Moses Lake	1558	4377	4801	13,374	0	0
Quincy	1	3	1569	4,323	0	0
Royal City	0	0	18	54	304	786
Soap Lake	171	438	292	807	335	873
Warden	0	0	663	1,770	0	0
Wilson Creek	20	39	119	261	3	6
Unincorporated	6801	12267	11895	23,100	2566	4161
Total	**9,186**	**18,687**	**21,996**	**50,634**	**4949**	**9,624**

17.5.2 Property

Property damage from wildfires can be severe and can significantly alter entire communities. Tables 17-2 through Table 17-4 display the number of homes in the various Regime zones within the planning area and their values.

Table 17-2.

Planning Area Structures Exposed to Regime I, 0-35 Years, Low to Mixed Severity

Jurisdiction	Buildings Exposed	Assessed Value Structure	Contents	**Total**	% of AV
Coulee City	0	0	0	**0**	0.00%
Electric City	0	0	0	**0**	0.00%
Ephrata	73	6,833,000	5,561,000	**12,394,000**	2.10%
George	104	9,223,000	7,736,000	**16,959,000**	75.84%
Grand Coulee	2	84,000	84,000	**168,000**	0.22%
Hartline	0	0	0	**0**	0.00%
Krupp	0	0	0	**0**	0.00%
Mattawa	456	44,492,000	41,678,000	**86,170,000**	100.00%
Moses Lake	1558	320,732,000	266,443,000	**587,175,000**	37.10%
Quincy	1	17,190,000	13,752,000	**30,942,000**	7.64%
Royal City	0	0	0	**0**	0.00%
Soap Lake	171	10101000	8406000	**18507000**	16.93%
Warden	0	0	0	**0**	0.00%
Wilson Creek	20	1,436,000	1,242,000	**2,678,000**	16.24%
Unincorporated	6,801	771,614,000	670,249,000	**1,441,863,000**	32.59%
Total	**9,186**	**1,181,705,000**	**1,015,151,000**	**2,196,856,000**	**28.86%**

Table 17-3.

Planning Area Structures Exposed to Regime III, 35-200 Years, Low to Mixed Severity

Jurisdiction	Buildings Exposed	Assessed Value Structure	Contents	**Total**	% of AV
Coulee City	16	697,000	556,000	**1,253,000**	3.58%
Electric City	14	1,660,000	1,375,000	**3,035,000**	3.67%
Ephrata	2520	292,788,000	245,997,000	**538,785,000**	91.15%
George	53	2,958,000	2,446,000	**5,404,000**	24.16%
Grand Coulee	1	154,000	123,000	**277,000**	0.36%
Hartline	5	383,000	306,000	**689,000**	6.25%
Krupp	30	1,647,000	1,440,000	**3,087,000**	57.22%
Mattawa	0	0	0	**0**	0.00%
Moses Lake	4801	543,444,000	445,876,000	**989,320,000**	62.51%
Quincy	1569	205,351,000	168,938,000	**374,289,000**	92.36%
Royal City	18	2035000	1625000	**3660000**	6.47%

Soap Lake	292	27235000	22038000	**49273000**	45.08%
Warden	663	58,326,000	49,159,000	**107,485,000**	100.00%
Wilson Creek	119	6,985,000	5,876,000	**12,861,000**	77.98%
Unincorporated	11,895	1,302,649,000	1,115,603,000	**2,418,252,000**	54.66%
Total	**21,996**	**2,446,312,000**	**2,061,358,000**	**4,507,670,000**	**59.21%**

Table 17-4.

Planning Area Structures Exposed to Regime IV, 35-200 Years, Replacement Severity

Jurisdiction	Buildings Exposed	Assessed Value Structure	Contents	**Total**	% of AV
Coulee City	333	17,857,000	14,975,000	**32,832,000**	93.85%
Electric City	541	43,404,000	36,324,000	**79,728,000**	96.33%
Ephrata	126	20,679,000	16,861,000	**37,540,000**	6.35%
George	0	0	0	**0**	0.00%
Grand Coulee	611	40,675,000	35,611,000	**76,286,000**	99.42%
Hartline	117	5,563,000	4,768,000	**10,331,000**	93.75%
Krupp	13	913,000	809,000	**1,722,000**	31.92%
Mattawa	0	0	0	**0**	0.00%
Moses Lake	0	0	0	**0**	0.00%
Quincy	0	0	0	**0**	0.00%
Royal City	304	28751000	24180000	**52931000**	93.53%
Soap Lake	335	22632000	18891000	**41523000**	37.99%
Warden	0	0	0	**0**	0.00%
Wilson Creek	3	306,000	275,000	**581,000**	3.52%
Unincorporated	2,566	244,403,000	212,675,000	**457,078,000**	10.33%
Total	**4,949**	**425,183,000**	**365,369,000**	**790,552,000**	**10.38%**

17.5.3 Critical Facilities and Infrastructure

Currently there are 21 registered Tier II hazardous material containment sites in Wildfire Regime zones. During a wildfire event, these materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition they could leak into surrounding areas, saturating soils and seeping into surface waters, and have a disastrous effect on the environment.

In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most road and railroads would be without damage except in the worst scenarios. Power lines are the most at risk to wildfire because most are made of wood and susceptible to burning. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Table 17-5.

Critical Facilities Exposed to Wildfire Hazards

	Regime I	Regime III	Regime IV
Medical and Health Services	4	8	3
Government Function	8	46	16
Protective Function	9	24	12
Schools	12	50	15
Other Critical Function	26	76	45
Bridges	65	133	49
Water	2	10	1
Waste Water	1	4	2
Power	2	7	3
Communications	4	8	6
Total	**149**	**272**	**41**

17.5.4 Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, dictating in part the types, structure, and spatial extent of native vegetation. However, wildfires can cause severe environmental impacts:

- Damaged Fisheries—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- Soil Erosion—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- Spread of Invasive Plant Species—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- Disease and Insect Infestations—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- Destroyed Endangered Species Habitat—Catastrophic fires can have devastating consequences for endangered species.
- Soil Sterilization—Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

Many ecosystems are adapted to historical patterns of fire occurrence. These patterns, called “fire regimes,” include temporal attributes (e.g., frequency and seasonality), spatial attributes (e.g., size and spatial complexity), and magnitude attributes (e.g., intensity and severity), each of which have ranges of natural variability. Ecosystem stability is threatened when any of the attributes for a given fire regime diverge from its range of natural variability.

17.5.5 Historic Fire Regime

Alterations of historic fire regimes and vegetation dynamics have occurred in many landscapes in the U.S., including Grant County through the combined influence of land management practices, fire exclusion, insect and disease outbreaks, climate change, and the invasion of non-native plan species. Anthropogenic influences to wildfire occurrence have been witnessed through arson, incidental ignition from industry (e.g., logging, railroad, sporting activities), and other factors. Likewise, wildfire abatement practices has reduced the spread of wildfires after ignition. This has reduced the risk to both the ecosystem and the urban populations living in or near forestlands, such as the Grant County.

The LANDFIRE Project produces maps of simulated historical fire regimes and vegetation conditions using the LANDSUM landscape succession and disturbance dynamics model. The LANDFIRE Project also produces maps of current vegetation and measurements of current vegetation departure from simulated historical reference conditions. These maps support fire and landscape management planning outlined in the goals of the National Fire Plan, Federal Wildland Fire Management Policy, and the Healthy Forests Restoration Act. The Simulated Historical Mean Fire Return Interval (MFRI) data layer quantifies the average number of years between fires under the presumed historical fire regime. This data layer is derived from vegetation and disturbance dynamics simulations using LANDSUM. LANDSUM simulates fire dynamics as a function of vegetation dynamics, topography, and spatial context, in addition to variability introduced by dynamic wind direction and speed, frequency of extremely dry years, and landscape-level fire characteristics.

The Simulated Historical Fire Regime Groups utilized in LANDFIRE (HFRG, 2006), categorize simulated MFRI and fire severities into five fire regimes defined in the Interagency Fire Regime Condition Class Guidebook, as follows:

Regime 1: 0-35 year frequency, low to mixed severity

Regime II: 0-35 year frequency, replacement severity

Regime III: 35-200 year frequency, low to mixed severity

Regime IV: 35 -200 year frequency, replacement severity

Regime V: 200+ year frequency, any severity

17.6. VULNERABILITY

Structures, above-ground infrastructure, critical facilities and natural environments are all vulnerable to the wildfire hazard. There is currently no validated damage function available to support wildfire mitigation planning. Except as discussed in this section, vulnerable populations, property, infrastructure and environment are assumed to be the same as described in the section on exposure.

17.6.1 Population

There are no recorded incidents of loss of life from wildfires within the planning area. Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal; therefore, injuries and casualties were not estimated for the wildfire hazard.

Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxics (formaldehyde, benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility.

Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

17.6.2 Property

Loss estimations for the wildfire hazard are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the assessed value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 17-6 lists the loss estimates for the general building stock for jurisdictions that have an exposure to a wildfire Regime zones.

Table 17-6.
Buildings Vulnerable to Wildfire Hazard

City	Assessed Value	10% Damage	30% Damage	50% Damage
Coulee City	34,983,000	3,498,300	10,494,900	17,491,500
Electric City	82,763,000	8,276,300	24,828,900	41,381,500
Ephrata	591,108,000	59,110,800	177,332,400	295,554,000
George	22,363,000	2,236,300	6,708,900	11,181,500
Grand Coulee	76,731,000	7,673,100	23,019,300	38,365,500
Hartline	11,020,000	1,102,000	3,306,000	5,510,000
Krupp	5,395,000	539,500	1,618,500	2,697,500
Mattawa	86,170,000	8,617,000	25,851,000	43,085,000
Moses Lake	1,576,495,000	157,649,500	472,948,500	788,247,500
Quincy	405,231,000	40,523,100	121,569,300	202,615,500
Royal City	56,591,000	5,659,100	16,977,300	28,295,500
Soap Lake	109,303,000	10,930,300	32,790,900	54,651,500
Warden	107,485,000	10,748,500	32,245,500	53,742,500
Wilson Creek	16,492,000	1,649,200	4,947,600	8,246,000
Unincorporated	4,408,289,000	440,828,900	1,322,486,700	2,204,144,500
Total	**7,590,419,000**	**759,041,900**	**2,277,125,700**	**3,795,209,500**

17.6.3 Critical Facilities and Infrastructure

Critical facilities of wood frame construction are especially vulnerable during wildfire events. In the event of wildfire, there would likely be little damage to most infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk from wildfire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Wildfire typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

17.7. FUTURE TRENDS IN DEVELOPMENT

Urbanization tends to alter the natural fire regime, and can create the potential for the expansion of urbanized areas into wildland areas. The expansion of the wildland urban interface can be managed with strong land use and building codes. The planning area is well equipped with these tools and this planning process has asked each planning partner to assess its capabilities with regards to the tools. As Grant County experiences future growth, it is anticipated that the exposure to this hazard will remain as assessed or even decrease over time due to these capabilities.

17.8. SCENARIO

A major conflagration in Grant County might begin with a wet spring, adding to fuels already present. Flashy fuels would build throughout the spring. The summer could see the onset of insect infestation. A dry summer could follow the wet spring, exacerbated by dry hot winds. Carelessness with combustible materials or a tossed lit cigarette, or a sudden lighting storm could trigger a multitude of small isolated fires.

The embers from these smaller fires could be carried miles by hot, dry winds. The deposition zone for these embers could be in wooded areas or an interface zones. Fires that start in flat areas move slower, but wind still pushes them. It is not unusual for a wildfire pushed by wind to burn the ground fuel and later climb into the crown and reverse its track. This is one of many ways that fires can escape containment, typically during periods when response capabilities are overwhelmed. These new small fires would most likely merge. Suppression resources would be redirected from protecting the natural resources to saving more remote subdivisions.

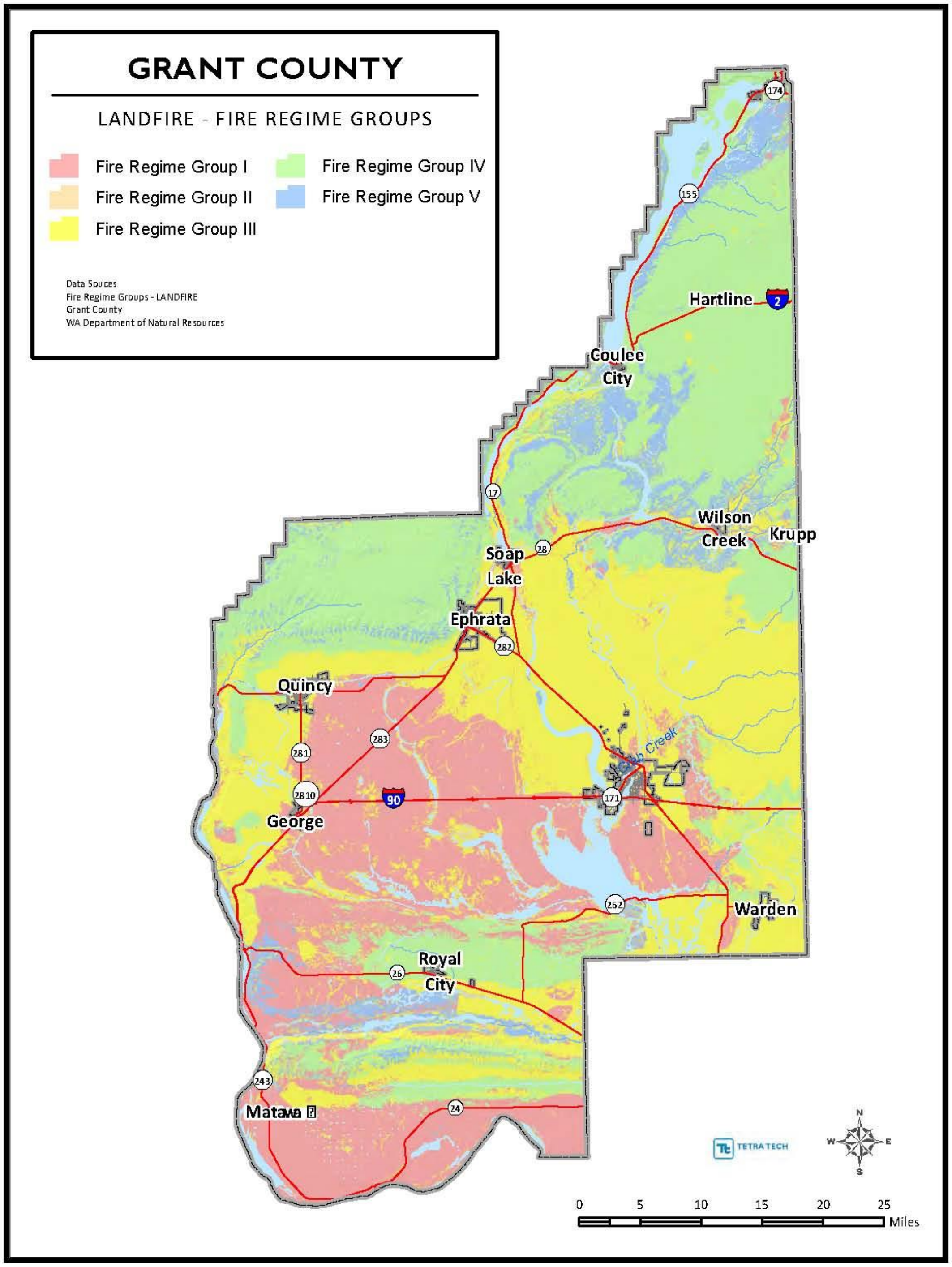
The worst-case scenario would include an active fire season throughout the American west, spreading resources thin. Firefighting teams would be exhausted or unavailable. Many federal assets would be responding to other fires that started earlier in the season.

To further complicate the problem, heavy rains could follow, causing flooding and landslides and releasing tons of sediment into rivers, permanently changing floodplains and damaging sensitive habitat and riparian areas. Such a fire followed by rain could release millions of cubic yards of sediment into streams for years, creating new floodplains and changing existing ones. With the forests removed from the watershed, stream flows could easily double. Floods that could be expected every 50 years may occur every couple of years. With the streambeds unable to carry the increased discharge because of increased sediment, the floodplains and floodplain elevations would increase.

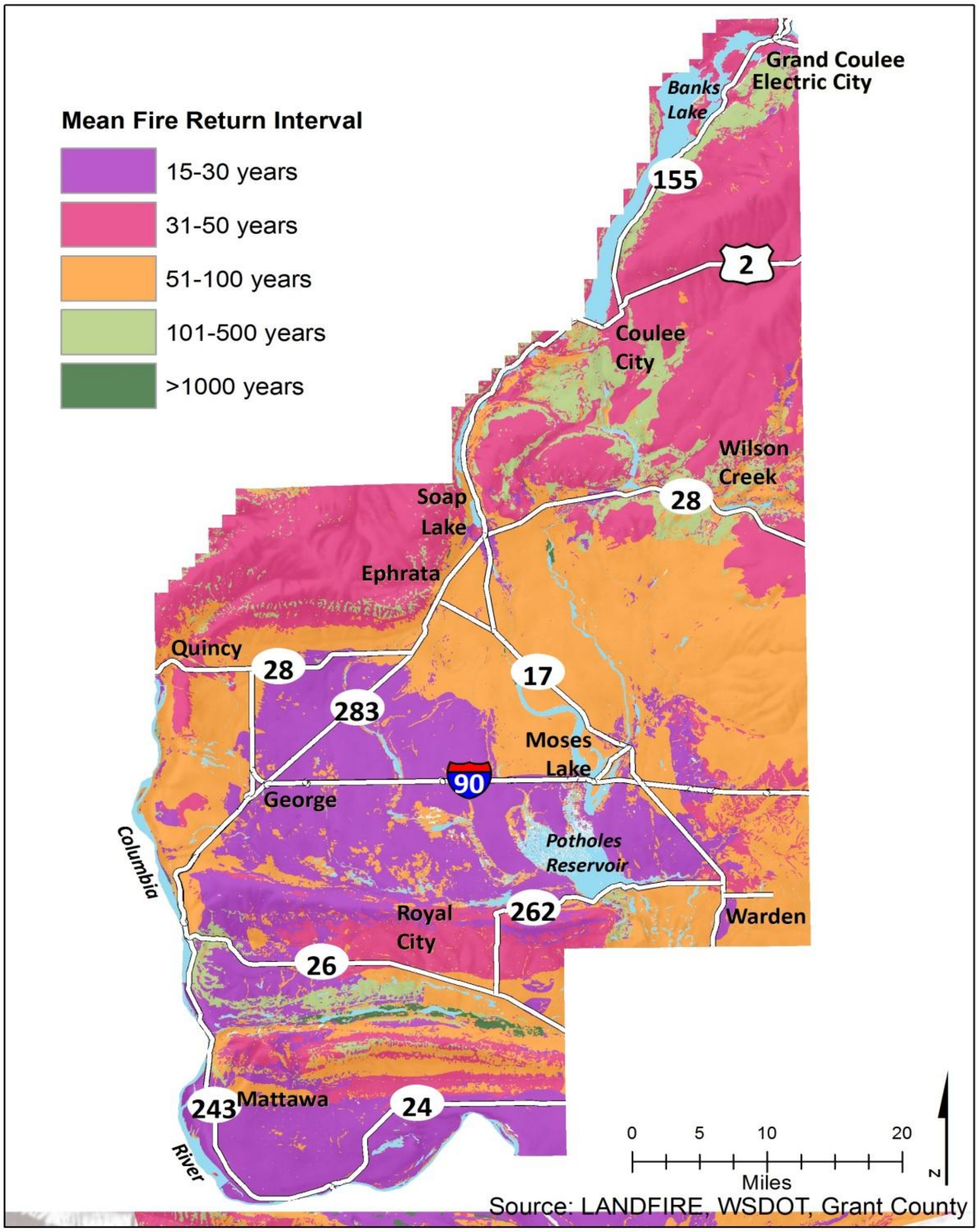
17.9. ISSUES

The major issues for wildfire are the following:

- Public education and outreach to people living in or near the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, and advance identification of evacuation routes and safe zones.
- Wildfires could cause landslides as a secondary natural hazard.
- Climate change could affect the wildfire hazard.
- Future growth into interface areas should continue to be managed.
- Area fire districts need to continue to train on wildland-urban interface events.
- Vegetation management activities. This would include enhancement through expansion of the target areas as well as additional resources.
- Regional consistency of higher building code standards such as residential sprinkler requirements and prohibitive combustible roof standards.
- Expand certifications and qualifications for fire department personnel. Ensure that all firefighters are trained in basic wildfire behavior, basic fire weather, and that all company officers and chief level officers are trained in the wildland command and strike team leader level.



Map 17-1 Grant County Fire Regime Groups



Map 17-2: Grant County Mean Fire Return Interval

PART 3—TECHNOLOGICAL HAZARD PROFILES

CHAPTER 18.
HAZARDOUS MATERIALS

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CHAPTER 19.
PIPELINE

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CHAPTER 20.
PUBLIC HEALTH

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CHAPTER 21.
RADIOLOGICAL INCIDENTS

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CHAPTER 22.
TERRORISM

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PART 4—RISK RANKING AND MITIGATION STRATEGY

CHAPTER 23.
PLANNING AREA RISK RANKING

A risk ranking was performed for the hazards of concern described in this plan. This risk ranking assesses the probability of each hazard's occurrence as well as its likely impact on the people, property, and economy of the planning area. The risk ranking was conducted via facilitated brainstorming sessions and in consideration of data generated by HAZUS-MH using methodologies promoted by FEMA. The results are used in establishing mitigation priorities.

23.1. PROBABILITY OF OCCURRENCE

The probability of occurrence of a hazard is indicated by a probability factor based on likelihood of annual occurrence:

- High—Hazard event is likely to occur within 25 years (Probability Factor = 3)
- Medium—Hazard event is likely to occur within 100 years (Probability Factor =2)
- Low—Hazard event is not likely to occur within 100 years (Probability Factor =1)
- No exposure—There is no probability of occurrence (Probability Factor = 0)

The assessment of hazard frequency is generally based on past hazard events in the area. **Error! Reference source not found.** summarizes the probability assessment for each hazard f concern for this plan.

23.2. IMPACT

Hazard impacts were assessed in three categories: impacts on people, impacts on property and impacts on the local economy. Numerical impact factors were assigned as follows:

- **People**—Values were assigned based on the percentage of the total ***population exposed*** to the hazard event. The degree of impact on individuals will vary and is not measurable, so the calculation assumes for simplicity and consistency that all people exposed to a hazard because they live in a hazard zone will be equally impacted when a hazard event occurs. It should be noted that planners can use an element of subjectivity when assigning values for impacts on people. Impact factors were assigned as follows:
  - High—50 percent or more of the population is exposed to a hazard (Impact Factor = 3)
  - Medium—25 percent to 49 percent of the population is exposed to a hazard (Impact Factor = 2)
  - Low—25 percent or less of the population is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the population is exposed to a hazard (Impact Factor = 0)
- **Property**—Values were assigned based on the percentage of the total ***property value exposed*** to the hazard event:
  - High—30 percent or more of the total assessed property value is exposed to a hazard (Impact Factor = 3)

  - Medium—15 percent to 29 percent of the total assessed property value is exposed to a hazard (Impact Factor = 2)
  - Low—14 percent or less of the total assessed property value is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the total assessed property value is exposed to a hazard (Impact Factor = 0)
- **Economy**—Values were assigned based on the percentage of the total ***property value vulnerable*** to the hazard event. Values represent estimates of the loss from a major event of each hazard in comparison to the total assessed value of the property exposed to the hazard. For some hazards, such as wildfire, landslide and severe weather, vulnerability was considered to be the same as exposure due to the lack of loss estimation tools specific to those hazards. Loss estimates separate from the exposure estimates were generated for the earthquake and flood hazards using HAZUS-MH.
  - High—Estimated loss from the hazard is 20 percent or more of the total assessed property value (Impact Factor = 3)
  - Medium—Estimated loss from the hazard is 10 percent to 19 percent of the total assessed property value (Impact Factor = 2)
  - Low—Estimated loss from the hazard is 9 percent or less of the total assessed property value (Impact Factor = 1)
  - No impact—No loss is estimated from the hazard (Impact Factor = 0)

The impacts of each hazard category were assigned a weighting factor to reflect the significance of the impact. These weighting factors are consistent with those typically used for measuring the benefits of hazard mitigation actions: impact on people was given a weighting factor of 3; impact on property was given a weighting factor of 2; and impact on the operations was given a weighting factor of 1.

23.3. RISK RATING AND RANKING

The risk rating for each hazard was determined by multiplying the probability factor by the sum of the weighted impact factors for people, property and operations, as summarized in Table 23-1. The hazards ranked as being of highest concern are severe storm, drought, and wildfire. Hazards ranked as being of medium concern are volcano, flood and earthquake. The hazards ranked as being of lowest concern are dam failure and landslide. Table 23-2 shows the hazard risk ranking.

TABLE 23-1. GRANT COUNTY RISK RATING					
Natural Hazard Event	**Probability Factor**	**Impact: People (weight x3)**	**Impact: Property (weight x2)**	**Impact: Economy (weight x1)**	**Risk Rating (max score = 54)**
Dam Failure	Med 2	3	2	1	**12**
Drought	High 3	3	6	3	**36**
Earthquake	Med 2	3	2	2	**14**
Flood	High 3	3	2	1	**18**
Landslide	Low 1	3	2	1	**6**
Severe Weather	High 3	6	6	2	**42**
Volcano	Med 2	9	6	1	**32**
Wildfire	High 3	3	6	2	**33**

TABLE 233-2. HAZARD RISK RANKING		
Rank	Hazard Type	Risk Rating Score (Probability x Impact)
1	Severe Weather	42
2	Drought	36
3	Wildfire	33
4	Volcano	32
5	Flood	18
6	Earthquake	14
7	Dam Failure	12
8	Landslide	6
	Technological Hazard Type	*Reserved for subsequent plan update*
1		
2		
3		
4		

CHAPTER 24.
MITIGATION ALTERNATIVES

Catalogs of hazard mitigation alternatives were developed that present a broad range of alternatives to be considered for use in the planning area, in compliance with 44CFR (Section 201.6.c.3.ii). One catalog was developed for each hazard of concern evaluated in this plan. The catalogs for each hazard are listed in Table 24-1 through 24-8. The catalogs present alternatives that are categorized in two ways:

- By what the alternative would do:
  - Manipulate a hazard
  - Reduce exposure to a hazard
  - Reduce vulnerability to a hazard
  - Increase the ability to respond to or be prepared for a hazard
- By who would have responsibility for implementation:
  - Individuals
  - Businesses
  - Government.

Hazard mitigation initiatives recommended in this plan were selected from among the alternatives presented in the catalogs. The catalogs provide a baseline of mitigation alternatives that are backed by a planning process, are consistent with the planning partners' goals and objectives, and are within the capabilities of the partners to implement. However, not all the alternatives meet all the planning partners' selection criteria.

**TABLE 24-1.
CATALOG OF MITIGATION ALTERNATIVES—DAM FAILURE**

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. None	1. Remove dams 2. Remove levees 3. Harden dams	1. Remove dams 2. Remove levees 3. Harden dams
Reduce Exposure		
1. Relocate out of dam failure inundation areas.	1. Replace earthen dams with hardened structures	1. Replace earthen dams with hardened structures 2. Relocate critical facilities out of dam failure inundation areas. 3. Consider open space land use in designated dam failure inundation areas.
Reduce Vulnerability		
1. Elevate home to appropriate levels.	1. Flood-proof facilities within dam failure inundation areas	1. Adopt higher regulatory floodplain standards in mapped dam failure inundation areas. 2. Retrofit critical facilities within dam failure inundation areas.
Increase Preparation or Response Capability		
1. Learn about risk reduction for the dam failure hazard. 2. Learn the evacuation routes for a dam failure event. 3. Educate yourself on early warning systems and the dissemination of warnings.	1. Educate employees on the probable impacts of a dam failure. 2. Develop a Continuity of Operations Plan.	1. Map dam failure inundation areas. 2. Enhance emergency operations plan to include a dam failure component. 3. Institute monthly communications checks with dam operators. 4. Inform the public on risk reduction techniques 5. Adopt real-estate disclosure requirements for the re-sale of property located within dam failure inundation areas. 6. Consider the probable impacts of climate in assessing the risk associated with the dam failure hazard. 7. Establish early warning capability downstream of listed high hazard dams. 8. Consider the residual risk associated with protection provided by dams in future land use decisions.

TABLE 24-2.
CATALOG OF MITIGATION ALTERNATIVES—DROUGHT

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
None	None	Groundwater recharge through stormwater management
Reduce Exposure		
None	None	Identify and create groundwater backup sources
Reduce Vulnerability		
1. Drought-resistant landscapes 2. Reduce water system losses 3. Modify plumbing systems (through water saving kits)	1. Drought-resistant landscapes 2. Reduce private water system losses	1. Water use conflict regulations 2. Reduce water system losses 3. Distribute water saving kits
Increase Preparation or Response Capability		
1. Practice active water conservation	1. Practice active water conservation	1. Public education on drought resistance 2. Identify alternative water supplies for times of drought; mutual aid agreements with alternative suppliers 3. Develop drought contingency plan 4. Develop criteria “triggers” for drought-related actions 5. Improve accuracy of water supply forecasts 6. Modify rate structure to influence active water conservation techniques

**TABLE 24-3.
CATALOG OF MITIGATION ALTERNATIVES—EARTHQUAKE**

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
None	None	None
Reduce Exposure		
1. Locate outside of hazard area (off soft soils)	1. Locate or relocate mission-critical functions outside hazard area where possible	1. Locate critical facilities or functions outside hazard area where possible
Reduce Vulnerability		
1. Retrofit structure (anchor house structure to foundation) 2. Secure household items that can cause injury or damage (such as water heaters, bookcases, and other appliances) 3. Build to higher design	1. Build redundancy for critical functions and facilities 2. Retrofit critical buildings and areas housing mission-critical functions	1. Harden infrastructure 2. Provide redundancy for critical functions 3. Adopt higher regulatory standards
Increase Preparation or Response Capability		
1. Practice “drop, cover, and hold” 2. Develop household mitigation plan, such as creating a retrofit savings account, communication capability with outside, 72-hour self-sufficiency during an event 3. Keep cash reserves for reconstruction 4. Become informed on the hazard and risk reduction alternatives available. 5. Develop a post-disaster action plan for your household	1. Adopt higher standard for new construction; consider “performance-based design” when building new structures 2. Keep cash reserves for reconstruction 3. Inform your employees on the possible impacts of earthquake and how to deal with them at your work facility. 4. Develop a Continuity of Operations Plan	1. Provide better hazard maps 2. Provide technical information and guidance 3. Enact tools to help manage development in hazard areas (e.g., tax incentives, information) 4. Include retrofitting and replacement of critical system elements in capital improvement plan 5. Develop strategy to take advantage of post-disaster opportunities 6. Warehouse critical infrastructure components such as pipe, power line, and road repair materials 7. Develop and adopt a Continuity of Operations Plan 8. Initiate triggers guiding improvements (such as <50% substantial damage or improvements) 9. Further enhance seismic risk assessment to target high hazard buildings for mitigation opportunities. 10. Develop a post-disaster action plan that includes grant funding and debris removal components.

TABLE 24-4.
CATALOG OF MITIGATION ALTERNATIVES—FLOOD

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. Clear stormwater drains and culverts 2. Institute low-impact development techniques on property	1. Clear stormwater drains and culverts 2. Institute low-impact development techniques on property	1. Maintain drainage system 2. Institute low-impact development techniques on property 3. Dredging, levee construction, and providing regional retention areas 4. Structural flood control, levees, channelization, or revetments. 5. Stormwater management regulations and master planning 6. Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff
Reduce Exposure		
1. Locate outside of hazard area 2. Elevate utilities above base flood elevation 3. Institute low impact development techniques on property	1. Locate business critical facilities or functions outside hazard area 2. Institute low impact development techniques on property	1. Locate or relocate critical facilities outside of hazard area 2. Acquire or relocate identified repetitive loss properties 3. Promote open space uses in identified high hazard areas via techniques such as: planned unit developments, easements, setbacks, greenways, sensitive area tracks. 4. Adopt land development criteria such as planned unit developments, density transfers, clustering 5. Institute low impact development techniques on property 6. Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff
Reduce Vulnerability		
1. Retrofit structures (elevate structures above base flood elevation) 2. Elevate items within house above base flood elevation 3. Build new homes above base flood elevation 4. Flood-proof existing structures	1. Build redundancy for critical functions or retrofit critical buildings 2. Provide flood-proofing measures when new critical infrastructure must be located in floodplains	1. Harden infrastructure, bridge replacement program 2. Provide redundancy for critical functions and infrastructure 3 Adopt appropriate regulatory standards, such as: increased freeboard standards, cumulative substantial improvement or damage, lower substantial damage threshold; compensatory storage, non-conversion deed restrictions. 4. Stormwater management regulations and master planning. 5. Adopt “no-adverse impact” floodplain management policies that strive to not increase the flood risk on downstream communities.

TABLE 24-4.
CATALOG OF MITIGATION ALTERNATIVES—FLOOD

Personal Scale	Corporate Scale	Government Scale
Increase Preparation or Response Capability		
1. Buy flood insurance 2. Develop household mitigation plan, such as retrofit savings, communication capability with outside, 72-hour self-sufficiency during and after an event	1. Keep cash reserves for reconstruction 2. Support and implement hazard disclosure for the sale/re-sale of property in identified risk zones. 3. Solicit cost-sharing through partnerships with other stakeholders on projects with multiple benefits.	1. Produce better hazard maps 2. Provide technical information and guidance 3. Enact tools to help manage development in hazard areas (stronger controls, tax incentives, and information) 4. Incorporate retrofitting or replacement of critical system elements in capital improvement plan 5. Develop strategy to take advantage of post-disaster opportunities 6. Warehouse critical infrastructure components 7. Develop and adopt a Continuity of Operations Plan 8. Consider participation in the Community Rating System 9. Maintain existing data and gather new data needed to define risks and vulnerability 10.Train emergency responders 11.Create a building and elevation inventory of structures in the floodplain 12.Develop and implement a public information strategy 13.Charge a hazard mitigation fee 14.Integrate floodplain management policies into other planning mechanisms within the planning area. 15 Consider the probable impacts of climate change on the risk associated with the flood hazard 16.Consider the residual risk associated with structural flood control in future land use decisions 17.Enforce National Flood Insurance Program 18.Adopt a Stormwater Management Master Plan

TABLE 24-5.
CATALOG OF MITIGATION ALTERNATIVES—LANDSLIDE

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. Stabilize slope (dewater, armor toe) 2. Reduce weight on top of slope 3. Minimize vegetation removal and the addition of impervious surfaces.	1. Stabilize slope (dewater, armor toe) 2. Reduce weight on top of slope	1. Stabilize slope (dewater, armor toe) 2. Reduce weight on top of slope
Reduce Exposure		
1. Locate structures outside of hazard area (off unstable land and away from slide-run out area)	1. Locate structures outside of hazard area (off unstable land and away from slide-run out area)	1. Acquire properties in high-risk landslide areas. 2. Adopt land use policies that prohibit the placement of habitable structures in high-risk landslide areas.
Reduce Vulnerability		
1. Retrofit home.	1. Retrofit at-risk facilities.	1. Adopt higher regulatory standards for new development within unstable slope areas. 2. Armor/retrofit critical infrastructure against the impact of landslides.
Increase Preparation or Response Capability		
1. Institute warning system, and develop evacuation plan 2. Keep cash reserves for reconstruction 3. Educate yourself on risk reduction techniques for landslide hazards.	1. Institute warning system, and develop evacuation plan 2. Keep cash reserves for reconstruction 3. Develop a Continuity of Operations Plan 4. Educate employees on the potential exposure to landslide hazards and emergency response protocol.	1. Produce better hazard maps 2. Provide technical information and guidance 3. Enact tools to help manage development in hazard areas: better land controls, tax incentives, information 4. Develop strategy to take advantage of post-disaster opportunities 5. Warehouse critical infrastructure components 6. Develop and adopt a Continuity of Operations Plan 7. Educate the public on the landslide hazard and appropriate risk reduction alternatives.

TABLE 24-6.
CATALOG OF MITIGATION ALTERNATIVES—SEVERE WEATHER

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
None	None	None
Reduce Exposure		
None	None	None
Reduce Vulnerability		
1. Insulate house 2. Provide redundant heat and power 3. Insulate structure 4. Plant appropriate trees near home and power lines ("Right tree, right place" National Arbor Day Foundation Program)	1. Relocate critical infrastructure (such as power lines) underground 2. Reinforce or relocate critical infrastructure such as power lines to meet performance expectations 3. Install tree wire	1. Harden infrastructure such as locating utilities underground 2. Trim trees back from power lines 3. Designate snow routes and strengthen critical road sections and bridges
Increase Preparation or Response Capability		
1. Trim or remove trees that could affect power lines 2. Promote 72-hour self-sufficiency 3. Obtain a NOAA weather radio. 4. Obtain an emergency generator.	1. Trim or remove trees that could affect power lines 2. Create redundancy 3. Equip facilities with a NOAA weather radio 4. Equip vital facilities with emergency power sources.	1. Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc. 2. Establish and enforce building codes that require all roofs to withstand snow loads 3. Increase communication alternatives 4. Modify land use and environmental regulations to support vegetation management activities that improve reliability in utility corridors. 5. Modify landscape and other ordinances to encourage appropriate planting near overhead power, cable, and phone lines 6. Provide NOAA weather radios to the public

TABLE 24-7.
CATALOG OF RISK REDUCTION MEASURES—VOLCANO

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
None	None	Limited success has been experienced with lava flow diversion structures
Reduce Exposure		
1. Relocate outside of hazard area, such as lahar zones	1. Locate mission critical functions outside of hazard area, such as lahar zones whenever possible.	1. Locate critical facilities and functions outside of hazard area, such as lahar zones, whenever possible.
Reduce Vulnerability		
None	1. Protect corporate critical facilities and infrastructure from potential impacts of severe ash fall (air filtration capability)	1. Protect critical facilities from potential problems associated with ash fall. 2. Build redundancy for critical facilities and functions.
Increase Preparation or Response Capability		
1. Develop and practice a household evacuation plan.	1. Develop and practice a corporate evacuation plan 2. Inform employees through corporate sponsored outreach 3. Develop a cooperative	1. Public outreach, awareness. 2. Tap into state volcano warning system to provide early warning to Grant County residents of potential ash fall problems.

TABLE 24-8.
CATALOG OF MITIGATION ALTERNATIVES—WILDFIRE

Personal Scale	Corporate Scale	Government Scale
Manipulate Hazard		
1. Clear potential fuels on property such as dry overgrown underbrush and diseased trees	1. Clear potential fuels on property such as dry underbrush and diseased trees	1. Clear potential fuels on property such as dry underbrush and diseased trees 2. Implement best management practices on public lands.
Reduce Exposure		
1. Create and maintain defensible space around structures 2. Locate outside of hazard area 3. Mow regularly	1. Create and maintain defensible space around structures and infrastructure 2. Locate outside of hazard area	1. Create and maintain defensible space around structures and infrastructure 2. Locate outside of hazard area 3. Enhance building code to include use of fire resistant materials in high hazard area.
Reduce Vulnerability		
1. Create and maintain defensible space around structures and provide water on site 2. Use fire-retardant building materials 3. Create defensible spaces around home	1. Create and maintain defensible space around structures and infrastructure and provide water on site 2. Use fire-retardant building materials 3. Use fire-resistant plantings in buffer areas of high wildfire threat.	1. Create and maintain defensible space around structures and infrastructure 2. Use fire-retardant building materials 3. Use fire-resistant plantings in buffer areas of high wildfire threat. 4. Consider higher regulatory standards (such as Class A roofing) 5. Establish biomass reclamation initiatives
Increase Preparation or Response Capability		
1. Employ techniques from the National Fire Protection Association's Firewise Communities program to safeguard home 2. Identify alternative water supplies for fire fighting 3. Install/replace roofing material with non-combustible roofing materials.	1. Support Firewise community initiatives. 2. Create /establish stored water supplies to be utilized for fire fighting.	1. More public outreach and education efforts, including an active Firewise program 2. Possible weapons of mass destruction funds available to enhance fire capability in high-risk areas 3. Identify fire response and alternative evacuation routes 4. Seek alternative water supplies 5. Become a Firewise community 6. Use academia to study impacts/solutions to wildfire risk 7. Establish/maintain mutual aid agreements between fire service agencies. 8. Create/implement fire plans 9. Consider probable impacts of climate change on risk associated with wildfire hazards in future land use decisions.

CHAPTER 25. AREA-WIDE MITIGATION INITIATIVES

25.1. SELECTED COUNTY-WIDE MITIGATION INITIATIVES

The planning partners and the Steering Committee determined that some initiatives from the mitigation catalogs could be implemented to provide hazard mitigation benefits countywide. Volume 2 of this plan lists the recommended countywide initiatives, the lead agency for each, and the proposed timeline in each jurisdiction annex. The parameters for the timeline are as follows:

- Short Term = to be completed in 1 to 5 years
- Long Term = to be completed in greater than 5 years
- Ongoing = currently being funded and implemented under existing programs.

25.2. BENEFIT/COST REVIEW

44 CFR requires the prioritization of the action plan according to a benefit/cost analysis of the proposed projects and their associated costs (Section 201.6.c.3iii). The benefits of proposed projects were weighed against estimated costs as part of the project prioritization process. The benefit/cost analysis was not of the detailed variety required by FEMA for project grant eligibility under the Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) grant program. A less formal approach was used because some projects may not be implemented for up to 10 years, and associated costs and benefits could change dramatically in that time. Therefore, a review of the apparent benefits versus the apparent cost of each project was performed. Parameters were established for assigning subjective ratings (high, medium, and low) to the costs and benefits of these projects.

Cost ratings were defined as follows:

- **High**—Existing funding will not cover the cost of the project; implementation would require new revenue through an alternative source (for example, bonds, grants, and fee increases).
- **Medium**—The project could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years.
- **Low**—The project could be funded under the existing budget. The project is part of or can be part of an ongoing existing program.

Benefit ratings were defined as follows:

- **High—**Project will provide an immediate reduction of risk exposure for life and property.
- **Medium—**Project will have a long-term impact on the reduction of risk exposure for life and property, or project will provide an immediate reduction in the risk exposure for property.
- **Low—**Long-term benefits of the project are difficult to quantify in the short term.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly.

For many of the strategies identified in this action plan, the partners may seek financial assistance under the HMGP or PDM programs, both of which require detailed benefit/cost analyses. These analyses will be performed on projects at the time of application using the FEMA benefit-cost model. For projects not seeking financial assistance from grant programs that require detailed analysis, the partners reserve the right to define “benefits” according to parameters that meet the goals and objectives of this plan.

25.3. COUNTY-WIDE ACTION PLAN PRIORITIZATION

Table 25-1 lists the priority of the countywide initiatives, using the same parameters used by each of the planning partners in selecting their initiatives. For a detailed list of countywide initiatives, please see Volume 2 of this plan. A qualitative benefit-cost review was performed for each of these initiatives. The priorities are defined as follows:

- **High Priority**—A project that meets multiple objectives (i.e., multiple hazards), has benefits that exceed cost, has funding secured or is an ongoing project and meets eligibility requirements for the HMGP or PDM grant program. High priority projects can be completed in the short term (1 to 5 years).
- **Medium Priority** —A project that meets goals and objectives, that has benefits that exceed costs, and for which funding has not been secured but that is grant eligible under HMGP, PDM or other grant programs. Project can be completed in the short term, once funding is secured. Medium priority projects will become high priority projects once funding is secured.
- **Low Priority**—A project that will mitigate the risk of a hazard, that has benefits that do not exceed the costs or are difficult to quantify, for which funding has not been secured, that is not eligible for HMGP or PDM grant funding, and for which the time line for completion is long term (1 to 10 years). Low priority projects may be eligible for other sources of grant funding from other programs.

**TABLE 25-1.
COUNTYWIDE MITIGATION INITIATIVES**

Description	County Department	Prioritization
CW-1—		
Protect aquifers through proper hazardous waste management and disposal, reducing vulnerability to drought.	Grant County Planning Department	1 of 1
CW-2—		
Saddle Mountain Road project to increase access.	Grant County Public Works Department	1 of 1
CW-3—		
Radio improvements strengthening existing structures to ensure interoperable communications.	Grant County Sheriff's Office	1 of 1
CW-4—		
Encourage and support regional LEPCs in Grant County	Grant County Department of Emergency Management	1 of 4
CW-5—		
Public education for hazard awareness	Grant County Department of Emergency Management	2 of 4
CW-6—		
Encourage land use planning that considers hazardous materials	Grant County Department of Emergency Management	3 of 4
CW-7—		
Improve and maintain emergency worker volunteer program	Grant County Department of Emergency Management	4 of 4

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Grant County
Hazard Mitigation Plan Update

APPENDIX A.
ACRONYMS AND DEFINITIONS

December 2013

APPENDIX A.
ACRONYMS AND DEFINITIONS

ACRONYMS

CFR—Code of Federal Regulations

cfs—cubic feet per second

CIP—Capital Improvement Plan

CRS—Community Rating System

DFIRM—Digital Flood Insurance Rate Maps

DHS—Department of Homeland Security

DMA —Disaster Mitigation Act

EAP—Emergency Action Plan

EPA—U.S. Environmental Protection Agency

ESA—Endangered Species Act

FEMA—Federal Emergency Management Agency

FERC—Federal Energy Regulatory Commission

FIRM—Flood Insurance Rate Map

FIS—Flood Insurance Study

GIS—Geographic Information System

HAZUS-MH—Hazards, United States-Multi Hazard

HMGP—Hazard Mitigation Grant Program

IBC—International Building Code

IRC—International Residential Code

MM—Modified Mercalli Scale

NEHRP—National Earthquake Hazards Reduction Program

NFIP—National Flood Insurance Program

NOAA—National Oceanic and Atmospheric Administration

NWS—National Weather Service

PDM—Pre-Disaster Mitigation Grant Program

PDI—Palmer Drought Index

PGA—Peak Ground Acceleration

PHDI—Palmer Hydrological Drought Index

SFHA—Special Flood Hazard Area

SHELDUS—Spatial Hazard Events and Losses Database for the US

SPI—Standardized Precipitation Index

USGS—U.S. Geological Survey

DEFINITIONS

100-Year Flood: The term “100-year flood” can be misleading. The 100-year flood does not necessarily occur once every 100 years. Rather, it is the flood that has a 1 percent chance of being equaled or exceeded in any given year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The Federal Emergency Management Agency (FEMA) defines it as the 1 percent annual chance flood, which is now the standard definition used by most federal and state agencies and by the National Flood Insurance Program (NFIP).

Acre-Foot: An acre-foot is the amount of water it takes to cover 1 acre to a depth of 1 foot. This measure is used to describe the quantity of storage in a water reservoir. An acre-foot is a unit of volume. One acre foot equals 7,758 barrels; 325,829 gallons; or 43,560 cubic feet. An average household of four will use approximately 1 acre-foot of water per year.

Asset: An asset is any man-made or natural feature that has value, including, but not limited to, people; buildings; infrastructure, such as bridges, roads, sewers, and water systems; lifelines, such as electricity and communication resources; and environmental, cultural, or recreational features such as parks, wetlands, and landmarks.

Base Flood: The flood having a 1% chance of being equaled or exceeded in any given year, also known as the “100-year” or “1% chance” flood. The base flood is a statistical concept used to ensure that all properties subject to the National Flood Insurance Program (NFIP) are protected to the same degree against flooding.

Basin: A basin is the area within which all surface water—whether from rainfall, snowmelt, springs, or other sources—flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains, and ridges. Basins are also referred to as “watersheds” and “drainage basins.”

Benefit: A benefit is a net project outcome and is usually defined in monetary terms. Benefits may include direct and indirect effects. For the purposes of benefit-cost analysis of proposed mitigation measures, benefits are limited to specific, measurable, risk reduction factors, including reduction in expected property losses (buildings, contents, and functions) and protection of human life.

Benefit/Cost Analysis: A benefit/cost analysis is a systematic, quantitative method of comparing projected benefits to projected costs of a project or policy. It is used as a measure of cost effectiveness.

Building: A building is defined as a structure that is walled and roofed, principally aboveground, and permanently fixed to a site. The term includes manufactured homes on permanent foundations on which the wheels and axles carry no weight.

Capability Assessment: A capability assessment provides a description and analysis of a community’s current capacity to address threats associated with hazards. The assessment includes two components: an inventory of an agency’s mission, programs, and policies, and an analysis of its capacity to carry them out. A capability assessment is an integral part of the planning process in which a community’s actions to reduce losses are identified, reviewed, and analyzed, and the framework for implementation is identified. The following capabilities were reviewed under this assessment:

- Legal and regulatory capability
- Administrative and technical capability
- Fiscal capability

Community Rating System (CRS): The CRS is a voluntary program under the NFIP that rewards participating communities (provides incentives) for exceeding the minimum requirements of the NFIP and completing activities that reduce flood hazard risk by providing flood insurance premium discounts.

Critical Area: An area defined by state or local regulations as deserving special protection because of unique natural features or its value as habitat for a wide range of species of flora and fauna. A sensitive/critical area is usually subject to more restrictive development regulations.

Critical Facility: Facilities and infrastructure that are critical to the health and welfare of the population. These become especially important after any hazard event occurs. For the purposes of this plan, critical facilities include:

- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic and/or water reactive materials;
- Hospitals, nursing homes, and housing likely to contain occupants who may not be sufficiently mobile to avoid death or injury during a hazard event.
- Police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers that are needed for disaster response before, during, and after hazard events, and
- Public and private utilities, facilities and infrastructure that are vital to maintaining or restoring normal services to areas damaged by hazard events.
- Government facilities.

Cubic Feet per Second (cfs): Discharge or river flow is commonly measured in cfs. One cubic foot is about 7.5 gallons of liquid.

Dam: Any artificial barrier or controlling mechanism that can or does impound 10 acre-feet or more of water.

Dam Failure: Dam failure refers to a partial or complete breach in a dam (or levee) that impacts its integrity. Dam failures occur for a number of reasons, such as flash flooding, inadequate spillway size, mechanical failure of valves or other equipment, freezing and thawing cycles, earthquakes, and intentional destruction.

Debris Avalanche: Volcanoes are prone to debris and mountain rock avalanches that can approach speeds of 100 mph.

Debris Flow: Dense mixtures of water-saturated debris that move down-valley; looking and behaving much like flowing concrete. They form when loose masses of unconsolidated material are saturated, become unstable, and move down slope. The source of water varies but includes rainfall, melting snow or ice, and glacial outburst floods.

Debris Slide: Debris slides consist of unconsolidated rock or soil that has moved rapidly down slope. They occur on slopes greater than 65 percent.

Disaster Mitigation Act of 2000 (DMA); The DMA is Public Law 106-390 and is the latest federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. Under the DMA, a pre-disaster hazard mitigation program and new requirements for the national post-disaster hazard mitigation grant program (HMGP) were established.

Drainage Basin: A basin is the area within which all surface water- whether from rainfall, snowmelt, springs or other sources- flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains and ridges. Drainage basins are also referred to as **watersheds** or **basins**.

Drought: Drought is a period of time without substantial rainfall or snowfall from one year to the next. Drought can also be defined as the cumulative impacts of several dry years or a deficiency of precipitation over an extended period of time, which in turn results in water shortages for some activity, group, or environmental function. A hydrological drought is caused by deficiencies in surface and subsurface water supplies. A socioeconomic drought impacts the health, well being, and quality of life or starts to have an adverse impact on a region. Drought is a normal, recurrent feature of climate and occurs almost everywhere.

Earthquake: An earthquake is defined as a sudden slip on a fault, volcanic or magmatic activity, and sudden stress changes in the earth that result in ground shaking and radiated seismic energy. Earthquakes can last from a few seconds to over 5 minutes, and have been known to occur as a series of tremors over a period of several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties may result from falling objects and debris as shocks shake, damage, or demolish buildings and other structures.

Exposure: Exposure is defined as the number and dollar value of assets considered to be at risk during the occurrence of a specific hazard.

Extent: The extent is the size of an area affected by a hazard.

Fire Behavior: Fire behavior refers to the physical characteristics of a fire and is a function of the interaction between the fuel characteristics (such as type of vegetation and structures that could burn), topography, and weather. Variables that affect fire behavior include the rate of spread, intensity, fuel consumption, and fire type (such as underbrush versus crown fire).

Fire Frequency: Fire frequency is the broad measure of the rate of fire occurrence in a particular area. An estimate of the areas most likely to burn is based on past fire history or fire rotation in the area, fuel conditions, weather, ignition sources (such as human or lightning), fire suppression response, and other factors.

Flash Flood: A flash flood occurs with little or no warning when water levels rise at an extremely fast rate

Flood Insurance Rate Map (FIRM): FIRMs are the official maps on which the Federal Emergency Management Agency (FEMA) has delineated the Special Flood Hazard Area (SFHA).

Flood Insurance Study: A report published by the Federal Insurance and Mitigation Administration for a community in conjunction with the community’s Flood Insurance rate Map. The study contains such background data as the base flood discharges and water surface elevations that were used to prepare the FIRM. In most cases, a community FIRM with detailed mapping will have a corresponding flood insurance study.

Floodplain: Any land area susceptible to being inundated by flood waters from any source. A flood insurance rate map identifies most, but not necessarily all, of a community’s floodplain as the Special Flood Hazard Area (SFHA).

Floodway: Floodways are areas within a floodplain that are reserved for the purpose of conveying flood discharge without increasing the base flood elevation more than 1 foot. Generally speaking, no development is allowed in floodways, as any structures located there would block the flow of floodwaters.

Floodway Fringe: Floodway fringe areas are located in the floodplain but outside of the floodway. Some development is generally allowed in these areas, with a variety of restrictions. On maps that have identified and delineated a floodway, this would be the area beyond the floodway boundary that can be subject to different regulations.

Fog: Fog refers to a cloud (or condensed water droplets) near the ground. Fog forms when air close to the ground can no longer hold all the moisture it contains. Fog occurs either when air is cooled to its dew point or the amount of moisture in the air increases. Heavy fog is particularly hazardous because it can restrict surface visibility. Severe fog incidents can close roads, cause vehicle accidents, cause airport delays, and impair the effectiveness of emergency response. Financial losses associated with transportation delays caused by fog have not been calculated in the United States but are known to be substantial.

Freeboard: Freeboard is the margin of safety added to the base flood elevation.

Frequency: For the purposes of this plan, frequency refers to how often a hazard of specific magnitude, duration, and/or extent is expected to occur on average. Statistically, a hazard with a 100-year frequency is expected to occur about once every 100 years on average and has a 1 percent chance of occurring any given year. Frequency reliability varies depending on the type of hazard considered.

Fujita Scale of Tornado Intensity: Tornado wind speeds are sometimes estimated on the basis of wind speed and damage sustained using the Fujita Scale. The scale rates the intensity or severity of tornado events using numeric values from F0 to F5 based on tornado wind speed and damage. An F0 tornado (wind speed less than 73 miles per hour (mph)) indicates minimal damage (such as broken tree limbs), and an F5 tornado (wind speeds of 261 to 318 mph) indicates severe damage.

Goal: A goal is a general guideline that explains what is to be achieved. Goals are usually broad-based, long-term, policy-type statements and represent global visions. Goals help define the benefits that a plan is trying to achieve. The success of a hazard mitigation plan is measured by the degree to which its goals have been met (that is, by the actual benefits in terms of actual hazard mitigation).

Geographic Information System (GIS): GIS is a computer software application that relates data regarding physical and other features on the earth to a database for mapping and analysis.

Hazard: A hazard is a source of potential danger or adverse condition that could harm people and/or cause property damage.

Hazard Mitigation Grant Program (HMGP): Authorized under Section 202 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the HMGP is administered by FEMA and provides grants to states, tribes, and local governments to implement hazard mitigation actions after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to disasters and to enable mitigation activities to be implemented as a community recovers from a disaster

Hazards U.S. Multi-Hazard (HAZUS-MH) Loss Estimation Program: HAZUS-MH is a GIS-based program used to support the development of risk assessments as required under the DMA. The HAZUS-MH software program assesses risk in a quantitative manner to estimate damages and losses associated with natural hazards. HAZUS-MH is FEMA's nationally applicable, standardized methodology and software program and contains modules for estimating potential losses from earthquakes, floods, and wind hazards. HAZUS-MH has also been used to assess vulnerability (exposure) for other hazards.

Hydraulics: Hydraulics is the branch of science or engineering that addresses fluids (especially water) in motion in rivers or canals, works and machinery for conducting or raising water, the use of water as a prime mover, and other fluid-related areas.

Hydrology: Hydrology is the analysis of waters of the earth. For example, a flood discharge estimate is developed by conducting a hydrologic study.

Intensity: For the purposes of this plan, intensity refers to the measure of the effects of a hazard.

Inventory: The assets identified in a study region comprise an inventory. Inventories include assets that could be lost when a disaster occurs and community resources are at risk. Assets include people, buildings, transportation, and other valued community resources.

Landslide: Landslides can be described as the sliding movement of masses of loosened rock and soil down a hillside or slope. Fundamentally, slope failures occur when the strength of the soils forming the slope exceeds the pressure, such as weight or saturation, acting upon them.

Lightning: Lightning is an electrical discharge resulting from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt," usually within or between clouds and the ground. A bolt of lightning instantaneously reaches temperatures approaching 50,000ºF. The rapid heating and cooling of air near lightning causes thunder. Lightning is a major threat during thunderstorms. In the United States, 75 to 100 Americans are struck and killed by lightning each year (see http://www.fema.gov/hazard/thunderstorms/thunder.shtm).

Liquefaction: Liquefaction is the complete failure of soils, occurring when soils lose shear strength and flow horizontally. It is most likely to occur in fine grain sands and silts, which behave like viscous fluids when liquefaction occurs. This situation is extremely hazardous to development on the soils that liquefy, and generally results in extreme property damage and threats to life and safety.

Local Government: Any county, municipality, city, town, township, public authority, school district, special district, intrastate district, council of governments (regardless of whether the council of governments is incorporated as a nonprofit corporation under State law), regional or interstate government entity, or agency or instrumentality of a local government; any Indian tribe or authorized tribal organization, or Alaska Native village or organization; and any rural community, unincorporated town or village, or other public entity.

Magnitude: Magnitude is the measure of the strength of an earthquake, and is typically measured by the Richter scale. As an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Mass movement: A collective term for landslides, mudflows, debris flows, sinkholes and lahars.

Mitigation: A preventive action that can be taken in advance of an event that will reduce or eliminate the risk to life or property.

Mitigation Actions: Mitigation actions are specific actions to achieve goals and objectives that minimize the effects from a disaster and reduce the loss of life and property.

Objective: For the purposes of this plan, an objective is defined as a short-term aim that, when combined with other objectives, forms a strategy or course of action to meet a goal. Unlike goals, objectives are specific and measurable.

Peak Ground Acceleration: Peak Ground Acceleration (PGA) is a measure of the highest amplitude of ground shaking that accompanies an earthquake, based on a percentage of the force of gravity.

Preparedness: Preparedness refers to actions that strengthen the capability of government, citizens, and communities to respond to disasters.

Presidential Disaster Declaration: These declarations are typically made for events that cause more damage than state and local governments and resources can handle without federal government assistance. Generally, no specific dollar loss threshold has been established for such declarations. A Presidential Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, designed to help disaster victims, businesses, and public entities.

Probability of Occurrence: The probability of occurrence is a statistical measure or estimate of the likelihood that a hazard will occur. This probability is generally based on past hazard events in the area and a forecast of events that could occur in the future. A probability factor based on yearly values of occurrence is used to estimate probability of occurrence.

Repetitive Loss Property: Any NFIP-insured property that, since 1978 and regardless of any changes of ownership during that period, has experienced:

- Four or more paid flood losses in excess of $1000.00; or
- Two paid flood losses in excess of $1000.00 within any 10-year period since 1978 or
- Three or more paid losses that equal or exceed the current value of the insured property.

Return Period (or Mean Return Period): This term refers to the average period of time in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).

Riverine: Of or produced by a river. Riverine floodplains have readily identifiable channels. Floodway maps can only be prepared for riverine floodplains.

Risk: Risk is the estimated impact that a hazard would have on people, services, facilities, and structures in a community. Risk measures the likelihood of a hazard occurring and resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage above a particular threshold due to occurrence of a specific type of hazard. Risk also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk Assessment: Risk assessment is the process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards. This process assesses the vulnerability of people, buildings, and infrastructure to hazards and focuses on (1) hazard identification; (2) impacts of hazards on physical, social, and economic assets; (3) vulnerability identification; and (4) estimates of the cost of damage or costs that could be avoided through mitigation.

Risk Ranking: This ranking serves two purposes, first to describe the probability that a hazard will occur, and second to describe the impact a hazard will have on people, property, and the economy. Risk estimates for the City are based on the methodology that the City used to prepare the risk assessment for this plan. The following equation shows the risk ranking calculation:

Risk Ranking = Probability + Impact (people + property + economy)

Robert T. Stafford Act: The Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 100-107, was signed into law on November 23, 1988. This law amended the Disaster Relief Act of 1974, Public Law 93-288. The Stafford Act is the statutory authority for most federal disaster response activities, especially as they pertain to FEMA and its programs.

Sinkhole: A collapse depression in the ground with no visible outlet. Its drainage is subterranean. It is commonly vertical-sided or funnel-shaped.

Special Flood Hazard Area: The base floodplain delineated on a Flood Insurance Rate Map. The SFHA is mapped as a Zone A in riverine situations and zone V in coastal situations. The SFHA may or may not encompass all of a community's flood problems

Stakeholder: Business leaders, civic groups, academia, non-profit organizations, major employers, managers of critical facilities, farmers, developers, special purpose districts, and others whose actions could impact hazard mitigation.

Stream Bank Erosion: Stream bank erosion is common along rivers, streams and drains where banks have been eroded, sloughed or undercut. However, it is important to remember that a stream is a dynamic and constantly changing system. It is natural for a stream to want to meander, so not all eroding banks are "bad" and in need of repair. Generally, stream bank erosion becomes a problem where development has limited the meandering nature of streams, where streams have been channelized, or where stream bank structures (like bridges, culverts, etc.) are located in places where they can actually cause damage to downstream areas. Stabilizing these areas can help protect watercourses from continued sedimentation, damage to adjacent land uses, control unwanted meander, and improvement of habitat for fish and wildlife.

Steep Slope: Different communities and agencies define it differently, depending on what it is being applied to, but generally a steep slope is a slope in which the percent slope equals or exceeds 25%. For this study, steep slope is defined as slopes greater than 33%.

Sustainable Hazard Mitigation: This concept includes the sound management of natural resources, local economic and social resiliency, and the recognition that hazards and mitigation must be understood in the largest possible social and economic context.

Thunderstorm: A thunderstorm is a storm with lightning and thunder produced by cumulonimbus clouds. Thunderstorms usually produce gusty winds, heavy rains, and sometimes hail. Thunderstorms are usually short in duration (seldom more than 2 hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry seasons.

Tornado: A tornado is a violently rotating column of air extending between and in contact with a cloud and the surface of the earth. Tornadoes are often (but not always) visible as funnel clouds. On a local scale, tornadoes are the most intense of all atmospheric circulations, and winds can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long.

Vulnerability: Vulnerability describes how exposed or susceptible an asset is to damage. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power. Flooding of an electric substation would affect not only the substation itself but businesses as well. Often, indirect effects can be much more widespread and damaging than direct effects.

Watershed: A watershed is an area that drains downgradient from areas of higher land to areas of lower land to the lowest point, a common drainage basin.

Wildfire: These terms refer to any uncontrolled fire occurring on undeveloped land that requires fire suppression. The potential for wildfire is influenced by three factors: the presence of fuel, topography, and air mass. Fuel can include living and dead vegetation on the ground, along the surface as brush and small trees, and in the air such as tree canopies. Topography includes both slope and elevation. Air mass includes temperature, relative humidity, wind speed and direction, cloud cover, precipitation amount, duration, and the stability of the atmosphere at the time of the fire. Wildfires can be ignited by lightning and, most frequently, by human activity including smoking, campfires, equipment use, and arson.

Windstorm: Windstorms are generally short-duration events involving straight-line winds or gusts exceeding 50 mph. These gusts can produce winds of sufficient strength to cause property damage. Windstorms are especially dangerous in areas with significant tree stands, exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and aboveground utility lines. A windstorm can topple trees and power lines; cause damage to residential, commercial, critical facilities; and leave tons of debris in its wake.

Zoning Ordinance: The zoning ordinance designates allowable land use and intensities for a local jurisdiction. Zoning ordinances consist of two components: a zoning text and a zoning map.

Grant County
Hazard Mitigation Plan Update

APPENDIX B.
PUBLIC OUTREACH

December 2013

APPENDIX B.
PUBLIC OUTREACH

The mitigation plan was posted on the Grant County Emergency Management webpage for comment. The opportunity to comment was provided via a survey link. Additionally, instructions for submitting written comments were given . Announcements for public review meetings were sent to the Grant County newspaper of record during the drafting stage. Two open public meetings were held: April 16, 2013 in Quincy, Washington at the Grant County Fire District #3 Station and April 23, 2013 at Big Bend Community College in Moses Lake, Washington for review of the plan update in draft.

Although the survey results cannot be generalized to a specific population, the following is a summary of information collected.

There were a total of 17 respondents to the online survey. All respondents reported that they live in Grant County. 87% of respondents indicated that the government (federal, state, or local emergency management) has provided them with useful information regarding natural hazards event preparation. 65% or more of respondents reported that their households have taken the following steps in preparation of a natural hazard event: first aid/cpr training, stored food and water, installed smoke detectors on eac h level of house, stored flashlights and batteries, stored a battery-powered radio and stored a fire extinguisher. The top three natural hazards respondents were concerned, very concerned or extremely concerned about were household and wildland fire, severe weather and earthquake. Property tax breaks, insurance premium discounts and grant funding were the top three incentives respondents selected that would encourage them to retrofit their homes in protection against natural disasters. The posting of this plan update online and other public outreach methods may increase awareness about natural hazards in Grant County. Respondents chose the internet, radio, and newspaper as the most effective methods for receiving hazard and disaster information.

Additional comments were received through public review meetings and the survey link. Comments about the mitigation plan update were of a positive nature. There was some feedback that technological hazards will need to be included in the plan update and more exploration for hazardous materials response is needed in Grant County.

Grant County
Hazard Mitigation Plan Update

APPENDIX C. EXAMPLE PROGRESS REPORT

December 2013

APPENDIX C.
EXAMPLE PROGRESS REPORT

Grant County
Hazard Mitigation Plan Update
Annual Progress Report

Reporting Period: *(Insert reporting period)*

Summary Overview of the Plan's Progress: The performance period for the Hazard Mitigation Plan became effective on _________with the final approval of the plan by FEMA. The initial performance period for this plan will be 5 years, with an anticipated update to the plan to occur before__________. As of the reporting period, the following overall progress can be reported:

- __ out of __ initiatives (__%) reported ongoing action toward completion.
- __ out of __ initiatives (__%) were reported as being complete.
- __ out of __ initiatives (___%) reported no action taken.

Purpose: The purpose of this report is to provide an annual update on the implementation of the action plan identified in the Grant County Hazard Mitigation Plan Update. The objective is to ensure that there is a continuing and responsive planning process that will keep the Hazard Mitigation Plan dynamic and responsive to the needs and capabilities of the partner jurisdictions. This report discusses the following:

- Natural hazard events that have occurred within the last year
- Changes in risk exposure within the planning area (all of Grant County)
- Mitigation success stories
- Review of the action plan
- Changes in capabilities that could impact plan implementation
- Recommendations for changes/enhancement.

The Hazard Mitigation Plan Steering Committee: The Hazard Mitigation Plan Steering Committee, made up of planning partners and stakeholders reviewed and approved this progress report at its annual meeting held on ______. It was determined through the plan's development process that a Steering Committee would remain in service to oversee maintenance of the plan. At a minimum, the Steering Committee will provide technical review and oversight on the development of the annual progress report. It is anticipated that there will be turnover in the membership annually, which will be documented in the progress reports. For this reporting period, the Steering Committee membership is as indicated in Table 1.

TABLE 1.
STEERING COMMITTEE MEMBERS

Name	Title	Jurisdiction/Agency

Natural Hazard Events within the Planning Area: During the reporting period, there were ____ natural hazard events in the planning area that had a measurable impact on people or property. A summary of these events is as follows:

- ______________________________
- ______________________________

Changes in Risk Exposure in the Planning Area: *(Insert brief overview of any natural hazard event in the planning area that changed the probability of occurrence or ranking of risk for the hazards addressed in the hazard mitigation plan)*

Mitigation Success Stories: *(Insert brief overview of mitigation accomplishments during the reporting period)*

Review of the Action Plan: Table 2 reviews the action plan, reporting the status of each initiative. Reviewers of this report should refer to the Hazard Mitigation Plan for more detailed descriptions of each initiative and the prioritization process.

Address the following in the "status" column of the following table:

- *Was any element of the initiative carried out during the reporting period?*
- *If no action was completed, why?*
- *Is the timeline for implementation for the initiative still appropriate?*

- *If the initiative was completed, does it need to be changed or removed from the action plan?*

TABLE 2.
ACTION PLAN MATRIX

Action Taken? (Yes or No)	Time Line	Priority	Status	Status (X, O,✓)
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				
Initiative #__—_______________________[description]				

Completion status legend:
✓= Project Completed
O = Action ongoing toward completion
X = No progress at this time

Changes That May Impact Implementation of the Plan: *(Insert brief overview of any significant changes in the planning area that would have a profound impact on the implementation of the plan. Specify any changes in technical, regulatory and financial capabilities identified during the plan's development)*

Recommendations for Changes or Enhancements: Based on the review of this report by the Hazard Mitigation Plan Steering Committee, the following recommendations will be noted for future updates or revisions to the plan:

- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________

Public review notice: *The contents of this report are considered to be public knowledge and have been prepared for total public disclosure. Any questions or comments regarding the contents of this report should be directed to:*

Grant County Department of Emergency Management
3953 Airway Dr. NE Bldg. 2
Moses Lake, WA 98837
(509) 762-1462

Grant County
Hazard Mitigation Plan Update

APPENDIX D.
PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS

December 2013

APPENDIX D. PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS

To Be Provided With Final Release